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24-hour Movement Guidelines Compliance: Development of Surveillance and Monitoring Instruments

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“O conhecimento é a conquista mais valiosa que um ser humano pode obter.”

Immanuel Kant

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Resumo

O sono, o comportamento sedentário e a atividade física são os comportamentos do movimento que compõem o período de 24-horas. Uma avaliação precisa e padronizada destes comportamentos é da maior importância para investigadores, decisores políticos e clínicos.

A questão de investigação desta tese de doutoramento foi a seguinte: Como avaliar com precisão e exatidão os níveis cumprimento das recomendações comportamentos de movimento 24 horas, com acelerómetros e questionários que possam ser utilizados em projetos científicos de grande escala, em contextos clínicos e em sistemas de vigilância da saúde?

Esta tese é composta quatro artigos:

Os artigos I e II foram duas revisões sistemáticas com o objetivo de compreender as características e propriedades de medida dos questionários existentes que avaliam os comportamentos de movimento em adultos e idosos e crianças e adolescentes, respetivamente. As pesquisas foram realizadas em várias bases de dados eletrónicas e os resultados incluíram 60 questionários para adultos e idosos e 37 questionários para crianças e adolescentes, em ambas as revisões. Nenhum dos questionários apresentou validade de critério e fiabilidade adequadas, simultaneamente; e nenhum foi desenvolvido tendo em conta o paradigma dos comportamentos de movimento de 24 horas.

O artigo III teve como objetivo descrever o processo de desenvolvimento e a avaliação das propriedades de medida do Questionário de Movimento 24 horas, que foi desenvolvido para recolher informações sobre o sono, o comportamento sedentário e a atividade física entre adultos, durante o período de 24 horas. O questionário foi desenvolvido através da construção de itens, seguida de testes de validade facial com utilizadores finais e de validade de conteúdo com especialistas. Foi avaliada a validade de critério com recurso à acelerometria e a validade convergente com recurso a um diário. Foi também realizado um teste de fiabilidade com sete dias de intervalo. Para estes estudos, 117 participantes foram recrutados. O Questionário de Movimento 24-horas demonstrou adequada validade facial e de conteúdo, e apresentou resultados de validade de critério e convergente moderados a muito fortes e resultados de fiabilidade fracos a excelentes. No que diz respeito ao cumprimento das recomendações de movimento de 24 horas, o questionário também mostrou uma percentagem de concordância forte a quase perfeita com a acelerometria e uma fiabilidade mínima a forte entre a primeira e a segunda administração.

O artigo IV foi uma revisão de escopo que teve como objetivo sintetizar a informação sobre os métodos de acelerometria utilizados para medir os comportamentos de movimento durante 24 horas, em todos os grupos etários. Foram realizadas pesquisas em várias bases de dados eletrónicas e os resultados incluíram 102 estudos. Três estudos em bebés, 15 em pré-escolares, 17 em crianças, 23 em adolescentes e 44 em adultos e idosos. Os resultados mostraram que os protocolos dos acelerómetros e as decisões metodológicas variavam substancialmente entre estudos.

Em conclusão, existe uma carência de questionários válidos e fiáveis que avaliem os comportamentos de movimento de 24 horas de uma forma integrada. Neste sentido, desenvolvemos um questionário, para avaliar os comportamentos de movimento de 24 horas em adultos, como resposta às lacunas encontradas nos questionários existentes. O Questionário de Movimento 24 horas é um instrumento válido e fiável para avaliar os comportamentos de movimento e o cumprimento das orientações em adultos. As suas propriedades de medida são comparáveis ou mesmo superiores às dos questionários existentes, enquanto representam uma carga semelhante para os participantes. Por último, existe uma variação considerável nos protocolos de acelerometria e nas decisões metodológicas aplicadas pelos investigadores para avaliar os comportamentos de movimento durante 24 horas. Por conseguinte, para aumentar a precisão e permitir a comparabilidade entre estudos e países, é necessário um consenso sobre as decisões metodológicas, o que representa um grande esforço devido à complexidade dos procedimentos, à variedade de marcas e tipos de acelerómetros disponíveis, e à multiplicidade de opções de programação.

Palavras-chave: COMPORTAMENTOS DO MOVIMENTO; QUESTIONÁRIOS; PROPRIEDADES DE MEDIDA; ACELEROMETRIA; TODAS AS FAIXAS ETÁRIAS

Abstract

Sleep, sedentary behaviour, and physical activity are the three movement behaviours that constitute a 24-hour period. An accurate and standardized assessment of these behaviours is of upmost importance for researchers, policy makers and clinicians.

The research question of this Doctorate thesis was: How to assess 24-hour movement behaviours levels precisely and accurately, with accelerometers and questionnaires that can be used in large scale scientific projects, clinical settings, and health surveillance systems?

This thesis comprises four papers:

Papers I and II were two systematic reviews aimed to understand the characteristics and measurement properties of existing questionnaires that evaluate movement behaviours in adults and older adults and children and adolescents, respectively. Searches were performed in several electronic databases and the results included 60 questionnaires for adults and older adults and 37 questionnaires for children and adolescents, in both reviews. None of the questionnaires showed adequate criterion validity and adequate reliability, simultaneously; and none was developed considering the 24-hour movement behaviour paradigm.

Paper III aimed to describe the development process and testing of the 24-hour Movement Questionnaire that was developed to capture information on sleep, sedentary behaviour, and physical activity among adults, during the full 24-hour period. The questionnaire was developed through item construction, followed by testing for face validity with end-users and content validity with experts. The questionnaire was then assessed for criterion validity against accelerometry, and convergent validity against a diary. Finally, a test-retest reliability was conducted seven days apart. For these studies, 117 participants were recruited. The 24-hour Movement Questionnaire showed content and face validity and performed moderate to very strong criterion and convergent validity results and poor to excellent reliability results. Regarding the compliance with the 24-hour movement guidelines, the questionnaire also showed a strong to almost perfect percentage of agreement with accelerometry, and minimal to strong reliability between the first and second administrations.

Paper IV was a scoping review aimed to synthesize information on the methods for 24-hour movement behaviour assessment using accelerometers, across all age groups. Searches were performed in several electronic databases and the results included 102 studies. Three studies in toddlers, 15 in preschoolers, 17 in children, 23 in adolescents and 44 in adults and older adults. The results showed that accelerometer protocols and methodological decisions varied substantially between reports.

In conclusion, there is a lack of valid and reliable questionnaires that assess 24-hour movement behaviours in an integrated way. In this sense, we have developed a questionnaire, to assess 24-hour movement behaviours in adults as a response to the gaps found in existing questionnaires. The 24-hour Movement Questionnaire is a valid and reliable tool for assessing movement behaviours and compliance with guidelines in adults. Its measurement properties are comparable or even higher to those of existing questionnaires, while posing a similar burden to participants. Finally, there is a considerable variation in accelerometer protocols and methodological decisions applied by researchers to assess 24-hour movement behaviours. Therefore, to enhance precision and enable comparability between studies and countries, a consensus on methodological decisions is necessary. This is a challenging endeavour due to the complexity of the procedures, the variety of available accelerometer brands and types, and the multitude of programming options.

Key-words: MOVEMENT BEHAVIOURS; QUESTIONNAIRES; MEASUREMENT PROPERTIES; ACCELEROMETRY; ALL AGE-GROUPS

List of abbreviations

13I-PAQ - 13-Item Physical Activity Questionnaire

3DPAR - 3-Day Physical Activity Recall

ACSM - American College of Sports Medicine

Active-Q - Web-Based Physical Activity Questionnaire

Adapt AAS - Adapted from Active Australia Survey

AHS - Australian Health Survey

ALSWH - SB Q - Australian Longitudinal Study on Women's Health - Sedentary Behaviour Questions

APAQ - Athens Physical Activity Questionnaire

APARQ - Adolescent Physical Activity Recall Questionnaire

AUC - Area Under the Curve

AWAS - Australian Women's Activity Survey

BRFSS - Behavioural Risk Factor Surveillance System

BRFSS Sleep - Behavioural Risk Factor Surveillance System sleep questions

CARDIA - CARDIA Physical Activity History

CCTQ - Children's ChronoType Questionnaire

CD – Cannot be determined

CHAMPS - Community Healthy Activities Model Program for Seniors

CHAMPS - SB - Community Health Activities Model Program for Seniors SB questions

CHAMPS+transport - Community Health Activities Model Program for Seniors physical activity self-report questionnaire + transport items

CI - Confidence Interval

CLASS - Proxy - The Children's Leisure Activities Study Survey - Proxy

College Alumnus Q - College Alumnus Questionnaire

COSMIN - COnsensus-based Standards for the selection of health Measurement Instruments

cp15s - Counts Per 15 Seconds

cPAQ - Computer-based physical activity questionnaire

Cpm - Counts Per Minute

CPS-3 sitting time - Cancer Prevention Study-3 Sedentary Time Survey

CRSP - Children's report of sleep patterns

CSHQ - Children's Sleep Habits Questionnaire

D - Duration

DABQ - Daily Activity Behaviours Questionnaire

DGS - General Directorate of Health

EAQT-SB - Eating and Activity Questionnaire Trial - Sedentary behaviour questions

EHIS - European Health Interview Survey

EMA - Ecological momentary assessments

ENERGY-C Q - ENERGY-child questionnaire

ENMO - Euclidean Norm Minus One

EPAQ - EPIC-Norfolk Physical Activity Questionnaire

EPIC PAQ - European Prospective Investigation into Cancer and Nutrition Physical Activity Questionnaire

EUPASMOS - European Union Physical Activity and Sport Monitoring System

F - Frequency

Fels PAQ - Fels Physical Activity Questionnaire

FPACQ - Flemish Physical Activity Computerized Questionnaire

g - Gravity

GAQ - GEMS Activity Questionnaire

Godin Q - Godin Questionnaire

GPAQ - Global Physical Activity Questionnaire

GPPAQ - General Practice Physical Activity Questionnaire

h – Hours

HBSC - Healthy Behaviour in School Children

HBSC PAQ - Health Behaviour in Schoolchildren Physical Activity Questionnaire

Helena SB Q - HELENA screen time-based sedentary behaviour questionnaire

HPAQ - Habitual Physical Activity Questionnaire

HRR - Heart Rate Reserve

HSE - Health Survey for England

HSK - Heart Smart Kids

HUNT 1 - Nord-Trøndelag Health Study PA Questionnaire

Hz - Hertz

I - Intensity

ICC - Intraclass Correlation Coefficients

IPAQ - International Physical Activity Questionnaire

IPAQ - SB - International Physical Activity Questionnaire - Sedentary Behaviour

IPAQ-WS - International Physical Activity Questionnaire – Walking Section

IPEQ - Incidental and Planned Exercise Questionnaire

JSRM - SB - Japanese-Language Self-reported Measures for Assessing Adults Domain-Specific Sedentary Time

K - Kappa's Coefficient

KPAS - Kaiser Physical Activity Survey

LAPAQ - The Longitudinal Ageing Study Amsterdam Physical Activity Questionnaire

LASA - Longitudinal Aging Study Amsterdam questionnaire

LoA - Limits of Agreement

LPA - Light Physical Activity

M - Mode

MARCA - Multimedia activity recall for children and adolescents

MCTQ - Munich ChronoType Questionnaire

MET - Metabolic Equivalent

MGLTEQ - Modified Godin-Leisure-Time Exercise Questionnaire

MHHP Q - Minnesota Heart Health Program Questionnaire

MHLAQ - Modified Historical Leisure Activity Questionnaire

Min - Minutes

Minnesota LTPA Q - Minnesota Leisure Time Physical Activity Questionnaire

Modified MOSPA-Q - Modified Version of the MONICA Optional Study on Physical Activity Questionnaire

MoMo - MoMo-Physical-Activity-Questionnaire for Adolescents

MovBeh – Movement Behaviours

MPA - Moderate Physical Activity

MPA and VPA S Q - Moderate and Vigorous Physical Activity Screening Questionnaire

MV - AAS1- Modified version Active Australia Survey 1

MV - AAS2 - Modified version Active Australia Survey 2

MVPA - Moderate to Vigorous Physical Activity

n - Sample Number

N.R. - Not Reported

NA - Not Applicable

NHANHES - US National Health and Nutrition Examination Survey

NPAQ-short - Nordic Physical Activity Questionnaire

NQPA - New Questionnaire on Physical Activity

O-O-S PAQ - Out-of-school physical activity questionnaire

OPAQ - Oxford Physical Activity Questionnaire

OQ - Own questionnaire

OSPAQ - Occupational Sitting and Physical Activity Questionnaire

P PACE+ PAM - PACE+ Adolescent Physical Activity Measure

PA - Physical Activity

PAAT - Physical Activity Assessment Tool

PAQ - Physical Activity Questionnaire

PAQ-EJ - Physical Activity Questionnaire for Elderly Japanese

PASE - The Physical Activity Scale for the Elderly

PNPAF - National Program for Physical Activity Promotion

PQPASB - Parental Questionnaire for Physical Activity and Sedentary Behaviour

PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analyses

PROMS - Patient-Reported Outcome Measures

Proxy and self-reported CLASS- Proxy and self - The Children's Leisure Activities Study Survey

PSQI - Pittsburgh Sleep Quality Index

PYPAA - Past year physical activity in adolescents

PYTPAQ - Past Year Total Physical Activity Questionnaire

Q 8 PPAQ - Question 8 of the Paffenbarger Physical Activity Questionnaire

QAPAQ - Quality Assessment of PA Questionnaire Checklist

QAPPA - Questionnaire d'Activité Physique pour les Personnes Âgées

r - Pearson's correlations coefficient

RADI - Rapid Assessment Disuse Index

rho - Spearman's correlations coefficient

RoB - Risk of Bias

s – Seconds

SAPAC - Self-Administered Physical Activity Checklist

SAYCARE SB Q A - South American Youth Cardiovascular and Environmental sedentary behaviour questionnaire for adolescents

SAYCARE SB Q C - South American Youth Cardiovascular and Environmental sedentary behaviour questionnaire for Children

SB - Sedentary Behaviour

SBQ - Sedentary Behaviour Questionnaire

SBSW - Self-reported sitting and breaks from sitting in the workplace

SD - Standard Deviation

SDC - Smallest Detectable Change

SEM - Standard Error of Measurement

SHAPES - School Health Action, Planning and Evaluation System physical activity questionnaire

SHS - Sleep habits survey

SI PA M - Single Item Physical Activity Measure

SITBRQ - Workplace Sitting Breaks Questionnaire

SIT-Q-7d - Last-7-day sedentary behaviour questionnaire

SPAQ - Self-report physical activity questionnaire

SPSS - Statistical Package for the Social Sciences

SQUASH - Short Questionnaire to Assess Health-enhancing physical activity

S-STQ - Sleep-schedule time questionnaire

STAQ - Sedentary, Transportation and Activity Questionnaire

STAR-Q - Sedentary Time and Activity Reporting Questionnaire

STQ - Sleep timing questionnaire

STQ - Sleep Timing Questionnaire

TASST - Taxonomy of Self-reported SB Tools

TPA - Total Physical Activity

TPAQ - Transport and Physical Activity Questionnaire

UK - United Kingdom

USA - United States of America

VIRTUE framework - Framework for Viable Integrative Research in Time-Use Epidemiology

VPA - Vigorous Physical Activity

WHO - World Health Organization

WSQ - Workforce Sitting Questionnaire

WSWQ - p-method - Workers' sitting- and walking-time questionnaire
Percentage Method

WSWQ- t-method - Workers' sitting- and walking-time questionnaire Time
Method

YLSBQ - Youth Leisure-time Sedentary Behaviour Questionnaire

YPAS - SB - SB question of the Yale Physical Activity Survey

YRBS - Youth Risk Behaviour Survey

Chapter 1

General introduction

Aims and dissertation structure

1.1. General introduction

In a 24-hour movement behaviour perspective, sleep, sedentary behaviour (SB) and physical activity (PA) are time-dependent because any change in one behaviour must be done at the expense of the others (Pedišić et al., 2017).

Given the population's levels of these behaviours, public health leaders, researchers, exercise physiologists and clinicians are increasingly interested in understanding how these (non)movement behaviors that make up the whole day (sleep, SB, PA), relate, conflate and impact health (Chaput et al., 2014; Saunders et al., 2016; Thompson et al., 2015; Tremblay et al., 2016). Therefore, there is a demand for innovative ways to promote active lifestyles and assess movement behaviours.

Similarly to other countries (Jurakić & Pedišić, 2019; Okely et al., 2017; Ross et al., 2020; Tremblay et al., 2016), our research group has begun to develop the Portuguese 24-hour Integrated Movement Guidelines. Although addressing unhealthy lifestyle behaviours is complex and requires a multi-sectoral and interdisciplinary approach, the existence of 24-hour movement guidelines is an important step in this endeavour. The 24-hour movement guidelines will serve as a foundation for future public health surveillance and provide practical information for public health leaders, researchers, exercise physiologists, and clinicians. Therefore, new measurement instruments are required to ensure that adherence to guidelines can be determined (Latimer-Cheung et al., 2016).

Although there are several reliable and valid instruments to measure PA (Chinapaw et al., 2010; Forsén et al., 2010; Helmerhorst et al., 2012; Hidding et al., 2018; Sattler et al., 2020; van Poppel et al., 2010), SB (Bakker et al., 2020; Dall et al., 2017; Hidding et al., 2017) and sleep (Ibáñez et al., 2018; Nascimento-Ferreira et al., 2016; Spruyt & Gozal, 2011b). There are few surveys that assess 24-hour movement behaviours in an integrated way. This poses a concern when determining movement behaviour levels and compliance with 24-hour Movement Guidelines. Such necessity aligns with one of the

priority areas of The Physical Activity Strategy for the European Region 2016–2025 from World Health Organization (WHO) *Supporting action through monitoring, surveillance, the provision of tools, enabling platforms, evaluation and research* (WHO, 2016), and with the WHO Global action plan on PA (WHO, 2019a) where it is recognized that more data on population PA and SB levels, across all ages and multiple domains, with reliable and timely information on the situation across Member States is instrumental to support national/regional policy-making, tracking trends and identification of the population subgroups in need for intervention. The same concerns may be applied to sleep (Morgenthaler et al., 2015).

Advances in the epidemiology of movement behaviours are also due, in part, to advances in activity monitor technology (Lee & Shiroma, 2014; Troiano et al., 2014). Accelerometry-based activity monitors collect time-stamped posture and activity information and have showed validity and reliability (Aadland & Ylvisåker, 2015; De Vries et al., 2009; Kelly et al., 2013; Lubans et al., 2011; Pedišić & Bauman, 2015; Van Cauwenberghe et al., 2011). Device measures are ideal for investigating levels and patterns of movement behaviours, as they allow quantification of overall levels of movement behaviours over entire days. They are precise and do not rely on recall memory. Additionally, a single accelerometer device can assess all movement behaviours over a 24-hour period, making them recommended for surveillance purposes (European Commission, 2008; Hallal et al., 2012). However, given the existence of several protocols and data management procedures, the accelerometers are not yet prepared to large surveillance (Pedišić & Bauman, 2015), and there is a need to standardize accelerometry processes (Burchartz et al., 2020; Migueles et al., 2017; Migueles et al., 2022; Taraldsen et al., 2012) to collect 24-hour data in studies with different age groups. On the other hand, in large epidemiological studies, clinical settings and national surveys self- or proxy-report measures are often the best instruments to assess movement behaviours, because these are practical, simple and affordable (Migueles et al., 2017; Sadeh, 2011; Strath et al., 2013).

In this context, there is a need to develop valid instruments specifically designed to assess compliance with the 24-hour movement guidelines. These instruments should consider the particular context of the Portuguese health surveillance systems and be suitable for use in future epidemiological studies and clinical practice. They will serve to evaluate and review policy actions, as recommended by the EU Physical Activity Guidelines (European Commission, 2008) and the WHO Global action plan on PA (WHO, 2019a).

1.2. Aims and dissertation structure

This dissertation is written in English following a Scandinavian model (collection of studies), following the Behavioural Epidemiology Framework which specifies a systematic sequence of studies on health-related behaviours, organized in six phases (1) “Establish Links Between Behaviours and Health”; 2) “Develop Methods for Measuring the Behaviour”; 3) “Characterizing Prevalence and Variations of Movement Behaviours in Populations”; 4) “Identify Factors That Influence the Behaviour”; 5) “Evaluate Interventions to Change the Behaviour” 6) “Translate Research Into Practice!”) (Owen et al., 2010; Sallis et al., 2000). This thesis aims to significantly contribute to the second phase of this framework.

Research question:

How to assess 24-hour Movement Behaviours levels precisely and accurately, with accelerometers and questionnaires that can be used in large scale scientific projects, clinical settings, and health surveillance systems?

To address this research question, defined the following objectives:

Objective 1:

To understand the characteristics and measurement properties of existing questionnaires that evaluate movement behaviours in adults and older adults.

- **Study 1 (Paper I): Rodrigues, B.,** Encantado, J., Carraça, E., Sousa-Sá, E., Lopes, L., Cliff, D., ... & Santos, R. (2022). Questionnaires measuring movement behaviours in adults and older adults: Content description and measurement properties. A systematic review. *PLoS one*, 17(3), e0265100.

Objective 2:

To understand the characteristics and measurement properties of existing questionnaires that evaluate movement behaviours in children and adolescents.

- **Study 2 (Paper II): Rodrigues, B.,** Encantado, J., Carraça, E., Martins, J., Marques, A., Lopes, L., ... & Santos, R. (2022). Questionnaires Measuring 24-Hour Movement Behaviours in Childhood and

Adolescence: Content Description and Measurement Properties—A Systematic Review. *Journal of Physical Activity and Health*, 20(1), 50-76.

Objective 3:

To adopt, adapt, or create *de novo* questionnaires to assess 24-hour movement behaviours, based on existing evidence.

- **Study 3 (Papers III):** 24h Movement Questionnaire (QMov24h) for Adults: Development Process and Measurement Properties (Submitted to *European Journal of Epidemiology*)

Objective 4:

To compile the evidence on the accelerometry methods used to assess 24-hour movement behaviours for different age-groups.

- **Study 4 (Paper IV):** Methodological choices on 24-hour movement behaviour assessment by accelerometry: a scoping review (Submitted to *Journal of Sport and Health Science*)

-

This dissertation was organized into 11 chapters.

In chapter 1 is provided the rationale for this dissertation, as well as the research questions and the objectives. In addition, the dissertation organization is presented.

Chapter 2 presents the general methods.

Chapter 3 presents the theoretical background.

Chapter 4, 5, 6 and 7 present the results of the papers I, II, III and IV, respectively.

These chapters are followed by a general discussion (Chapter 8) on the main findings, as well as the implications for clinical and research practice.

The main conclusions and the perspectives for future research in this field are presented in the Chapter 9.

The dissertation is concluded with the references which supported the General Introduction, the Theoretical Background and the Overall Discussion chapters

(Chapter 10), and the appendices relevant to the completion of this doctoral degree (Chapter 11).

Chapter 2

- General methods

2.1. General methods

A full description of the methods, procedures, measures, and analysis used in the papers included in this doctoral thesis are reported in detail in each paper and briefly described here.

This thesis is integrated in two main projects: 1) Portuguese integrated 24 hours Movement Guidelines (CEECIND/01069/2017; 2019); and 2) Dissemination, Monitoring and Surveillance of the Portuguese 24-Hour Movement Guidelines: making the whole day matter (PTDC/SAU-DES/0166/2021). The first project aims to develop integrated 24-hour Movement Guidelines for the Portuguese population of all age groups; and one of the main aims of the second project was adapt/adopt or develop de novo self-reported and proxy-report instruments to determine 24-hour movement guidelines compliance.

This thesis consisted of two systematic reviews on existing movement behaviours questionnaires for adults/older adults and children/adolescents (Papers I and II), a questionnaire development and validation study (Paper III) and a scoping review on methodological decisions on 24-hour movement behaviours assessed by accelerometry (Paper IV), in that order. The systematic reviews (Papers I, II) followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement for reporting systematic reviews and meta-analyses (Page et al., 2021). Searches were performed in several electronic databases, such as: PubMed, PsycINFO, SPORTDiscus, CINAHL, and EMBASE. They also followed the Consensus-based Standards for the selection of health Measurement Instruments (COSMIN) guidelines for systematic reviews of patient-reported outcome measures.

Prior to data collection for the development and validation study of a questionnaire on movement behaviours (Paper III), we obtained ethical approval from the Ethics Committee of the Faculty of Sports of the University of Porto (CEFADE 17 2022) and conducted the study in accordance with the Helsinki Declaration for Human Studies. The study followed the COSMIN and consisted of two parts. First, the development of the *24-hour Movement*

Questionnaire (QMov24h) through a three-stage approach: (i) item construction; (ii) content validity by experts and (iii) face validity by end-users. Secondly, assessment of the measurement properties of the final version of the questionnaire (criterion and convergent validity and test-retest reliability). To assess the measurement properties, the recruitment took place between May and July of 2023 and eligible participants were between 18 and 64.9 years old, residents in Portugal and able to read and write in Portuguese. Participants were selected using a convenience non-random strategic sampling procedure (i.e., snowball), and 130 participants were invited by direct contact. Criterion validity was assessed by comparing the questionnaire with accelerometry (Actigraph GT3X, Actigraph, Pensacola, Florida, USA). Participants wore the accelerometer on their right hip for seven days. To support and complete accelerometer data analysis, participants were also provided with a movement behaviour diary. The Actilife version 6.13.4 software (Actigraph, Pensacola, FL, USA) was used to download and analyse the data. Convergent validity was assessed using a diary. The statistical methods used to assess criterion and convergent validity were Spearman's correlations and Bland-Altman analysis. The percentage of agreement was also used to assess the adherence to the Canadian 24-hour movement guidelines. Reliability was assessed using test-retest by asking participants to complete the questionnaire seven days after the first administration. The statistical methods used were Intraclass Correlation Coefficients (ICCs) and Bland-Altman analysis. Both Cohen's kappa and the percentage of agreement were calculated to check reliability on compliance with the guidelines.

The scoping review (Paper IV) followed the PRISMA Extension for Scoping Reviews (PRISMA-ScR) (Tricco et al., 2018) and the methodology proposed by Arksey and O'Malley (Arksey & O'Malley, 2005), later updated by Levac et al. (Levac et al., 2010). Scoping reviews have been given little attention when compared with other types of reviews, such as the systematic reviews. Nevertheless, scoping reviews might be more appropriate when the research question is broader, and the aim does not comprise the evidence systematizing nor the studies quality assessment, such as in this study (Levac

et al., 2010). The protocol is publicly available in the Open Science Framework repository (OSF Repository Files). Searches were performed in several electronic databases, such as: PubMed, PsycINFO, SPORTDiscus and EMBASE.

Chapter 3

- Theoretical background

3.1. Theoretical background

This chapter presents a review of the scientific literature related to this doctoral thesis main aims and provides a rationale for the research undertaken.

This review of evidence follows the Behavioural Epidemiology Framework (Owen et al., 2010; Sallis et al., 2000), with a particular emphasis on the second phase – “Develop methods for measuring the behaviours”.

The Behavioural Epidemiology Framework is organized into six interconnected phases and is used to classify the health promotion and disease prevention research stages. Each phase of this framework builds on the previous phases, but the previous phases are also influenced by the following ones. The first phase – “Establish Links Between Behaviours and Health” – aims to provide a scientific basis for the subsequent phases, through studies on the dose-response associations between behaviours and health. Such evidence is important to produce useful insights for health guidelines development. The second phase – “Develop Methods for Measuring the Behaviour” – aims to develop valid and reliable instruments to accurately assess health-related behaviours. Better instruments can improve the results of the first phase, which shows the interdependence of all phases. The third phase – “Characterizing Prevalence and Variations of Movement Behaviours in Populations” - is used to understand populations levels of behaviours and to identify subgroups of the population in need of intervention. The fourth phase - “Identify Factors that Influence the Behaviour” aims to understand the determinants of the behaviours, which is useful in identifying characteristics of people who need intervention, as well as the social and environment factors influencing the behaviours. It also aims to evaluate behavioural theories and their impact on the behaviours. The fifth phase – “Evaluate Interventions to Change the Behaviour” is used to develop and evaluate intervention programs based on the first four phases. For example, the determinants identified in the fourth phase may be considered potential mediators of intervention effects and should be targeted for change in the interventions. Finally, the sixth phase – “Translate Research Into Practice” is the culmination of all phases, where the most effective interventions and the knowledge on the health effects of the behaviours should be replicated

in different contexts, before they can impact public health policies and clinical practices, through public health and clinical practice recommendations.

Given the aims of this thesis, this theoretical background is focused on the first, second, **third and sixth phases of this framework**.

3.1.1. New 24h Movement Behaviour Paradigm and Health Associations

During a 24-hour period, we can only be either asleep (i.e., a spontaneous and reversible state of rest characterized by inhibition of voluntary muscles and sensory activity, and by reduced consciousness, responsiveness to stimuli, and interactions with the environment (Carskadon & Rechtschaffen, 2011)), in SB (i.e., any waking behaviour characterized by an energy expenditure ≤ 1.5 metabolic equivalents (METs), while in a sitting, reclining, or lying posture; physical inactivity is an insufficient physical activity level to meet present physical activity recommendations (Tremblay, Aubert, et al., 2017)) or in PA (i.e., any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen et al., 1985)). In this sense, these three behaviours are interdependent (Pedišić et al., 2017). Considering the components of the 24-hour period (i.e., Sleep, SB and PA), any change in one behaviour must be at the expense of one of the other behaviours, making these components of the day, time-dependent and co-dependent (i.e., mutually exclusive). For example, an increase in SB duration, will be at the expense of PA and/or sleep duration, because a person can only engage in one of these activities, at any given time. In other words, movement behaviours are mutually exclusive and exhaustive parts of the 24-hour period (Pedišić et al., 2017).

Movement behaviours have traditionally been assessed in isolation, ignoring the intrinsic and empirical interactions between them (Carson et al., 2016; Chastin et al., 2015; Tremblay & Poitras, 2016). Evidence shows that sleep (Chaput et al., 2020), SB (Katzmarzyk et al., 2019; Saunders et al., 2020), and PA (Bennie et al., 2019), are associated with several health outcomes, and that inadequate levels of these behaviours increase the risk of mortality for all causes (Ramakrishnan et al., 2021; Yang et al., 2021; Zhou et al., 2021). However, recent evidence shows that these behaviours interact, conflate and

influence holistic health (Chaput et al., 2014; Clarke & Janssen, 2021; Janssen et al., 2020; Rollo et al., 2020; Saunders et al., 2016). For example, in children and adolescents, a combination of high PA/high sleep/low SB has positive results in adiposity and cardiometabolic health compared with those with a combination of low PA/low sleep/high SB (Saunders et al., 2016). Besides that, the compliance with the 24-hour movement guidelines showed positive associations with health-related quality of life, social-cognitive development, and behavioural and emotional problems in preschoolers, positive associations with global cognition, health-related quality of life, and healthy eating patterns in children, and positive associations with adiposity, fitness, and cardiometabolic, mental, social, and emotional health among children and adolescents (Rollo et al., 2020). The composition of 24-hour movement behaviours showed positive associations with cardiometabolic health, adiposity and fitness in adults, and with adiposity, fitness mental health and mortality risk in older adults (Rollo et al., 2020).

Given the co-dependency of movement behaviours, it is paramount to examine their health-related associations and explain the best combination of movement behaviours for a given health outcome in order to understand the complexity of the clustering and interactions of these behaviours on health (Pedišić et al., 2017). For this, some statistical procedures have been introduced into the field of movement behaviours. In 2009, the isotemporal substitution modelling procedure showed how reallocation of time between PA and SB was associated with weight change (Mekary et al., 2009). This statistical procedure is based on multiple linear regression models that aim to calculate the effect of reallocating (or replacing) time spent in one part of a time-use composition to another part of the time-use composition, on an outcome variable (Dumuid et al., 2019). For example, to estimate the effect of replacing minutes of light PA with minutes of MVPA on body composition, the resulting unstandardised regression coefficient for the included component (i.e., minutes of MVPA; independent variable) would represent the expected change for a one-unit increase (e.g., 1 minute) in the outcome variable (i.e., body

composition; dependent variable) due to an equivalent decrease in time spent in the excluded component (e.g., Light PA), whilst the total time is kept constant.

In recent years, isothermal substitution analysis has become an increasingly popular statistical procedure for identify the health effects of reallocating time between the three movement behaviours on health (Janssen et al., 2020; Vallance et al., 2017; Walmsley et al., 2021). Despite the advantages of isothermal substitution, this method treats units of time as absolute measures and consequently violates the compositional properties of time-use data, potentially leading to limited results (Pedišić, 2014).

To address these limitations, the Activity Balance Model was proposed by Pedišić (Pedišić, 2014), suggesting that instead of treating movement behaviours as independent risk factors, they should be analysed as part of a time-use composition using COmpositional Data Analysis (CODA). This is because the total sum of all movement behaviours is equals to 24-hour (i.e., 100% of the day). In other words, movement behaviours are proportions (in percentages) of a 24-hour period. The Activity Balance Model was developed under the assumptions that the proportions of time assigned to sleep, SB, standing, light PA and MVPA are perfectly collinear, all these behaviours may be positively and/or negatively associated with health, and mutual adjustments between all these behaviours are needed if their independent contributions to health should be determined. Therefore, this model includes the times spent in sleep, in SB, standing posture, light PA, and MVPA as independent variables and a selected health outcome as the dependent variable. The model can also be adjusted for potential confounders and stratified by different groups, to account for hypothesized moderating effects. The data can be collected using accelerometers, questionnaires, or a combination of both. When the data is not collected during all the 24-hour period, estimated times spent in different behaviours for each participant need to be linearly organized in the way that their sum gives 24 hours. This model can be applied in several situations: to study the independent and joint associations of the time spent in all movement behaviours with health outcomes; to identify the type of time allocation to these behaviours that are associated with negative health outcomes; and to determine

the ideal balance between the times spent in these behaviours to prevent negative health outcomes and achieve health benefits.

The introduction of these statistical methods as isotemporal substitution and CODA, together with the Activity Balance Model, has led to a new integrated concept in public health and behavioural epidemiological research: The time-use epidemiology (Pedišić et al., 2017). Time-use epidemiology is the study of determinants, incidence, distributions, and effects of health-related time-use patterns in populations, as well as methods for preventing unhealthy time-use patterns and achieving the optimal distribution of time for population health.

In this context, the Framework for Viable Integrative Research in Time-Use Epidemiology (VIRTUE framework) (Pedišić et al., 2017) has been proposed, incorporating key-elements of the Social-Ecological Approach (Sallis et al., 2006), the Behavioural Epidemiology Framework (Sallis et al., 2000), and the Activity Balance Model (Pedišić, 2014).

The VIRTUE framework is a model for future studies and integrates research in several areas: (i) methods of time-use epidemiology; (ii) outcomes of time-use composition; (iii) optimal time-use balance and its prevalence in populations; (iv) determinants and correlates of time-use composition; and (v) effectiveness of time-use interventions (Pedišić et al., 2017). The first area (i.e., methodological research in time-use epidemiology) foresees that studies in time-use epidemiology should use adequate measures of time use, such as validated questionnaires and accurate device measures. Also important in this area is the development and evaluation of classification systems for deriving health-related components of time use from survey and device-based data. The second area (i.e., Outcomes of health-related time-use compositions) describes how findings on health outcomes of movement behaviours influences public health strategies. Therefore, research in this area should investigate: the relationship between time-use composition and its hypothesised outcomes; the dose-response relationships between movement behaviours and their outcomes; the effects of reallocation of time between movement behaviours; and the mechanisms of the associations between movement behaviours

compositions and their outcomes. In the third area (i.e., Time-use composition: optimal balance, prevalence, and trends), research should inform policy makers and help shape public health strategies to determine the prevalence of appropriate and inappropriate movement behaviours. Thus, research should focus on: determining the average time spent in all movement behaviours; finding the ideal balance of time-use to prevent adverse health outcomes and achieve other benefits; determining the prevalence of movement behaviours patterns in populations and specific population subgroups; and identifying, as well as tracking trends of movement behaviours patterns over time. The fourth area (i.e., determinants of optimal time use) serves to understand what are the determinants that influence people to have better or worse movement behaviours patterns. In this sense, the research should identify the determinants of each movement behaviour, the ideal balance of movement behaviours, and the most common unhealthy movement behaviour patterns. Finally, in the fifth area (i.e., Time-use interventions) the research should focus on the development and implementation of effective interventions to improve movement behaviours patterns.

3.1.2. Movement Behaviours Assessment

There are several methods to assess each movement behaviour. These can be divided into subjective and device-based methods. Subjective assessments (e.g., questionnaires) rely on the individual recall to register movement behaviours; and device-based assessments (e.g., accelerometers) include monitors that use technology to assess movement behaviours directly, without human interference, and evaluate parameters such as, heart rate, body acceleration or step count. The choice of the most appropriate measure will depend on the researcher's objectives and resources.

The assessment of sleep can cover several main dimensions, such as: sleep duration, sleep timing, sleep quality and sleep variability (Sadeh, 2015). Sleep duration refers to the total amount of sleep obtained within a 24-hour period and can be classified as short, normal and long (Sateia, 2014). Sleep timing indicates when sleep occurs within a 24-hour period. Sleep quality is

subjectively defined as “good” or “poor” sleep. Other sleep dimensions include: through sleep latency (i.e., how long it takes to fall asleep after lying in bed); sleep wakings (i.e., how many times a person wakes up during the night, after falling asleep); wakefulness (i.e., how many minutes spent awake at night after fall asleep); sleep efficiency (i.e., amount of time spent sleeping while in bed); sleep fragmentation (i.e., multiple awakenings lasting less than 30 minutes, in the sleep period) (Ibáñez et al., 2018); And sleep variability (i.e., variations in sleep duration patterns over the week).

To accurately assess SB, there is a need to consider energy expenditure and body posture (e.g., lying, reclining, sitting, standing). This is because there are differences in energy expenditure between sitting and standing postures (Gibbs et al., 2017). The main issue in assessing SB is the fact that sedentary time often occurs in bouts throughout the day. Therefore, there is a need to define which components of SB to assess. The acronym SITT helps to define the components of SB (Tremblay et al., 2010). SITT is an acronym for four components: Sedentary bout frequency (i.e., number of bouts of a given duration); Interruptions of SB (i.e., interruption of any bout of SB); Time spent in SB (i.e., the duration of sitting); and type of behaviour engaged in while being sedentary (i.e., mode of sedentary behaviour, such as TV viewing, driving a car, or using a computer, etc.) (Kang & Rowe, 2015; Tremblay et al., 2010). Furthermore, SB can be categorized into four main domains based on the time, place and purpose in which it is being performed: leisure time (i.e., recreational activities); occupational (i.e., during work/job); transportation (i.e., purpose of going somewhere); and domestic (i.e., housework) (Ainsworth et al., 2013). Because SB occurs in all these components and domains, an ideal assessment of total SB should capture all components and domains, making total SB, a summary variable.

As for sleep and SB, when assessing PA, there is a need to define which dimensions and domains to assess. There are four dimensions that describe main PA characteristics: type of PA (i.e., specific activity performed); intensity (i.e., indicator of the metabolic demand); duration (i.e., time of the activity bout); and frequency (i.e., number of sessions per week or bouts per day). Regarding

the main PA domains, these are: leisure time PA (i.e., recreational activities); occupational PA (i.e., PA during work/job); transportation PA (i.e., commuting PA); and domestic PA (i.e., Housework) (Ainsworth et al., 2013).

PA outcomes can be quantified in various ways, such as energy expenditure (in kilocalories), metabolic equivalents (METs) and the duration (minutes and/or hours) spent in different PA intensities. Table 1 presents standard definitions for relative and absolute intensities. In summary, one liter of oxygen consumption equals approximately to 5 kcal of energy (Katch et al., 2011) and one MET is the resting energy expenditure during quiet sitting and is commonly defined as $3.5 \text{ mL O}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ or $\approx 250 \text{ mL/min}$ of oxygen consumed (Katch et al., 2011).

Table 1. Physical Activity Intensities

Intensity	Relative Intensity		Absolute Intensity	
	% Maximal Heart Rate	Rating of perceived exertion	Intensity	Metabolic equivalents
Very light	<30	<9	Sedentary	1–1.5
Light	30–49	9–10	Light	1.6–2.9
Moderate	50–69	11–12	Moderate	3.0–5.9
Hard	70–89	13–16	Vigorous	≥ 6.0
Very Hard	≥ 90	>16		
Maximal	100	20		

Adapted from Guide to the Assessment of Physical Activity: Clinical and Research Applications. A Scientific Statement from the American Heart Association (Strath et al., 2013).

3.1.2.1. Subjective measures

There are several types of movement behaviours' subjective measures, including diaries or logs, and questionnaires, for example.

Diaries or logs are used to obtain a detailed hour-by-hour and/or activity-by-activity register of movement behaviours. They can serve several purposes, such as, measuring levels and weekly patterns of movement behaviours, evaluating the psychometric properties of movement behaviours questionnaires and complementing device-based measures (e.g., to help the understanding of the type or domain of PA performed. The type of information registered in a log or diary usually includes when the activity started and stopped, its intensity, and type. Logs and diaries are completed by the participant through paper-and-

pencil or digital format (McTiernan, 2016; Sternfeld et al., 2012). Recently, researchers have developed ecological momentary assessments (EMA) to evaluate movement behaviours. These assessments send several prompts throughout the day for participants to report their current behaviour. EMA is a strategy that can simultaneously capture both behaviour and its influencing factors by allowing participants to report their current activity, location, and social surroundings (Dunton et al., 2011). The main advantages of logs, diaries, and EMA are their capability to provide “real-world” information on movement behaviours’ patterns. However, these methods also require a high level of adherence to reporting protocols and may cause reactivity (Atkin et al., 2012).

Questionnaires can be used to identify levels, dimensions and domains of movement behaviours through self- or proxy-reported responses or interviews. Self-reported questionnaires are appropriate when participants can answer the questions themselves. Proxy-reported questionnaires are used when participants have difficulty reporting their behaviours (e.g., children and adults with cognitive incapacity), and therefore a third party (e.g., caregivers) answers for them. Additionally, questionnaires could vary in the number of aspects they measure. For instance, questionnaires may focus on assessing movement behaviours in the previous day/week, the usual day/week or an individual’s history of movement behaviours levels and patterns over the life course.

Self-reported instruments can be used to assess movement behaviours in various ways, such as on paper, on a computer, or through face-to-face interviews. A common method for evaluating movement behaviours is through single-item questionnaires (e.g., How much time do you spend with MVPA in a week?) (Bauman & Richards, 2022). However, this method does not provide a complete representation of a movement behaviour, as it only provides overall information regarding movement behaviours’ levels and context. This may be insufficient for researchers seeking to develop tailored behaviour change interventions. Alternatively, questionnaires with a greater number of items are better to describe the context, types, and patterns of movement behaviours,

generating relevant information for the development of tailored behaviour change interventions (Bakker et al., 2020; Dall et al., 2017; Forsén et al., 2010; Helmerhorst et al., 2012; Ibáñez et al., 2018; Sattler et al., 2020; Terwee et al., 2010; van Poppel et al., 2010). Questionnaires can have various characteristics (i.e., qualitative attributes) that influence the measurement and help the researchers choose the best questionnaire for their specific purpose and resources. These characteristics are described in Table 2.

Table 2. Characteristic of movement behaviours questionnaires

Characteristic	Description	Example
Age group	What age group was the questionnaire developed for?	A questionnaire could be only validated for adults or for adults and older adults
Language and Country	For which country (or countries) and in which language (or languages) has the questionnaire been validated?	A questionnaire can be validated in one language (e.g., Portugal) or several languages (e.g., Portugal and English)
Mode of administration	How will the questionnaire be administered?	Interview, self-administration or proxy-administration
Movement behaviours targeted	What movement behaviours does the questionnaire focus on?	Sleep, SB, PA, or a combination of two or three movement behaviours
Domain	Which domains the questionnaire refers to (e.g., leisure, occupational, transportation, etc.). When there was no distinction between domains, they report total sleep/sedentary behaviour/physical activity.	A questionnaire can be focused on one specific domain (e.g., leisure), several (e.g., leisure and transportation), or nonspecific domain (e.g., Total PA)
Response method	What kind of response the questionnaire allows for?	Categorical/dichotomic responses (e.g., rating scale) or continuous responses (e.g., number of hours and minutes on sleep)
Measurement units	Which unit the researchers must use to evaluate the movement behaviours	METs, calories, minutes/day; hours/week, etc...
Scores	What are the final outputs from the questionnaire?	Total sleep/SB/PA; sleep duration; occupational PA/ SB, Activity level index, etc...
Recall period/Assessment	To which period the questionnaire refers to	Typical/last day/week, on week and weekend or whole

period		day/week without distinction for the types of days, etc....
Number of items	How many items compose the questionnaire?	Single item or multiple items
Parameters evaluated	In which movement behaviours characteristics are the questionnaire focused?	Frequency, duration, intensity and mode.

Legend: SB: Sedentary Behaviour; PA: Physical Activity

Self- or proxy-reported questionnaires are frequently used, mainly in large epidemiological studies and clinical settings, given their practicality, simplicity, affordability, and low burden for participants (in terms of time consuming and acceptability) (Lubans et al., 2011; J. Migueles et al., 2017; Sadeh, 2011; Strath et al., 2013). Moreover, these can collect valuable contextual information of the behaviours, such as type, domain and setting, that device-based measures are unable to do (Lippke et al., 2013). Nonetheless, assessing movement behaviours is challenging and complex, given that questionnaires are frequently prone to measurement errors and reporting bias due to misreporting, social desirability, language interpretation, complexity of the questionnaire, participants' age, memory and season (Sallis & Saelens, 2000), leading to an overestimation of PA's intensity and volume (Hussey et al., 2007). These are often exacerbated when questionnaires are applied to children, due to their increased difficulties in reporting past movement behaviours. Indeed, children's movement behaviours patterns (particularly PA) may be highly variable throughout the day/week (Baquet et al., 2007; Mattocks et al., 2008). Children also have lower ability to think abstractly and perform detailed recall (Sallis, 1991). Therefore, to overcome their limitations, proxy-report questionnaires for parents and caregivers are preferred (Corder et al., 2008; Harro, 1997; Loprinzi & Cardinal, 2011; Telford et al., 2004). Similarly, when assessing older adults, questionnaires may also be subject to memory recall constraints. Furthermore, if the methods used to develop questionnaires and their measurement properties are inadequate or unclear, there is a high risk of misclassification, bias, and inaccurate results (Lagerros, 2009).

There are several questionnaires to measure sleep, SB, PA and their combinations for different age groups and purposes. Table 3 shows some examples of questionnaires, divided by age-group and behaviour or combination.

Table 3. Movement Behaviours' Questionnaires

Behaviour	Questionnaire (Authors)	Abbreviation
Sleep	Children (3 to 10 years old)	
	Children's Sleep Habits Questionnaire (Owens et al., 2000)	CSHQ
	Own questionnaire (Sekine et al., 2002)	OQ
	Sleep-schedule time questionnaire (Werner et al., 2008)	S-STQ
	Children and adolescents (3 to 17.9 years old)	
	Children's ChronoType Questionnaire (Werner et al., 2009)	CCTQ
	Adolescents (11 to 17.9 years old)	
	Sleep habits survey (Wolfson et al., 2003)	SHS
	Sleep timing questionnaire (Tremaine et al., 2010)	STQ
	Children's report of sleep patterns (Meltzer et al., 2013)	CRSP
	Adults and older adults (≥ 18 year old)	
	BRFSS sleep questions (Jungquist et al., 2016)	BRFSS Sleep
	Pittsburgh Sleep Quality Index (Buysse et al., 1989)	PSQI
	Munich ChronoType Questionnaire (Roenneberg et al., 2003)	MCTQ
	Sleep Timing Questionnaire (Monk et al., 2003)	STQ
Sedentary Behaviour	Children (3 to 10 years old)	
	South American Youth Cardiovascular and Environmental sedentary behaviour questionnaire for Children (De Moraes et al., 2020)	SAYCARE SB Q C
	Adolescents (11 to 17.9 years old)	
	Eating and Activity Questionnaire Trial - Sedentary behaviour questions (Schmitz et al., 2004)	EAQT-SB

HELENA screen time-based sedentary behaviour questionnaire (Rey-López et al., 2012)	Helena SB Q
South American Youth Cardiovascular and Environmental sedentary behaviour questionnaire for adolescents (De Moraes et al., 2020)	SAYCARE SB Q A
Youth Leisure-time Sedentary Behaviour Questionnaire (Cabanas-Sánchez et al., 2018)	YLSBQ
Last-7-day sedentary behaviour questionnaire (Busschaert et al., 2015)	SIT-Q-7d
Adults (18 to 64.9 years old)	
International Physical Activity Questionnaire - Sedentary Behaviour (Rosenberg et al., 2008)	IPAQ-SB
Australian Longitudinal Study on Women's Health - Sedentary Behaviour Questions (Marshall et al., 2010)	ALSWH - SB Q
Self-reported sitting and breaks from sitting in the workplace (Sudholz et al., 2018)	SBSW
Workplace Sitting Breaks Questionnaire (Pedisic et al., 2014)	SITBRQ
Sedentary Behaviour Questionnaire (Rosenberg et al., 2010)	SBQ
SED-GIH (Larsson et al., 2019)	SED-GIH
Workforce Sitting Questionnaire (Chau et al., 2011)	WSQ
Japanese-Language Self-reported Measures for Assessing Adults Domain-Specific Sedentary Time (Ishii et al., 2018)	JSRM – SB
Adults and older adults (≥ 18 year old)	
Cancer Prevention Study-3 Sedentary Time Survey (Rees-Punia et al., 2019)	CPS-3 sitting time
Older Adults (≥ 65 year old)	
Longitudinal Aging Study Amsterdam questionnaire (Visser & Koster, 2013)	LASA
SB question of the Yale Physical Activity Survey (Gennuso et al., 2015)	YPAS - SB
Community Health Activities Model Program for Seniors SB questions (CHAMPS - SB) (Gennuso et	

	al., 2015)	
	Children (3 to 10 years old)	
	The Children's Leisure Activities Study Survey – Proxy (Telford et al., 2004)	CLASS - Proxy
	SAYCARE Physical Activity Questionnaire for children (Nascimento-Ferreira et al., 2018)	SAYCARE PA Q C
	Children and adolescents (3 to 17.9 years old)	
	Fels Physical Activity Questionnaire (Treuth et al., 2005)	Fels PAQ
	MoMo-Physical-Activity-Questionnaire for Adolescents (Jekauc et al., 2013)	MoMo
	Adolescents (11 to 17.9 years old)	
	Out-of-school physical activity questionnaire (Määttä et al., 2016)	O-O-S PAQ
	Habitual Physical Activity Questionnaire (Florindo et al., 2006)	HPAQ
	3-Day Physical Activity Recall (McMurray et al., 2004)	3DPAR
	Youth Risk Behaviour Survey (Prochaska et al., 2001)	YRBS
	Self-Administered Physical Activity Checklist (McMurray et al., 2004)	(SAPAC)
	Health Behaviour in Schoolchildren Physical Activity Questionnaire (Rangul et al., 2008)	HBSC PAQ
	Modified Godin-Leisure-Time Exercise Questionnaire (Gao et al., 2006)	MGLTEQ
	Oxford Physical Activity Questionnaire (Lubans et al., 2008)	OPAQ
	Adolescent Physical Activity Recall Questionnaire (Booth et al., 2002)	APARQ
	Past year physical activity in adolescents (Aaron et al., 1995)	PYPAA
	Computer-based physical activity questionnaire (Teo et al., 2013)	cPAQ
Physical Activity		

Single-item physical activity measure (Scott et al., 2015)	S-I PA M
Moderate and Vigorous Physical Activity Screening Questionnaire (Prochaska et al., 2001)	MPA and VPA S Q
PACE+ Adolescent Physical Activity Measure (Prochaska et al., 2001)	PACE + PAM
SAYCARE Physical Activity Questionnaire for adolescents (Nascimento-Ferreira et al., 2018)	SAYCARE PA Q A
The Children Leisure Activities Study Survey – Proxy and self-reported (Telford et al., 2004)	CLASS- Proxy and self
Adults (18 to 64.9 years old)	
Nord-Trøndelag Health Study PA Questionnaire (Kurtze et al., 2008)	HUNT 1
Past Year Total Physical Activity Questionnaire (Friedenreich et al., 2006)	PYTPAQ
Physical Activity Assessment Tool (Meriwether et al., 2006)	PAAT
Minnesota Leisure Time Physical Activity Questionnaire (Jacobs et al., 1993)	Minnesota LTPA Q
Single Item Physical Activity Measure (Milton et al., 2011)	SI PA M
Godin Questionnaire (Jacobs et al., 1993)	Godin Q
CARDIA Physical Activity History (Jacobs et al., 1993)	CARDIA
College Alumnus Questionnaire (Jacobs et al., 1993)	College Alumnus Q
Minnesota Heart Health Program Questionnaire (Jacobs et al., 1993)	MHHP Q
Modified Historical Leisure Activity Questionnaire (Chasan-Taber et al., 2002)	MHLAQ
Modified version Active Australia Survey 1 (Brown et al., 2008)	MV – AAS1
Modified version Active Australia Survey (Fjeldsoe et al., 2013)	MV – AAS2

	Adapted from Active Australia Survey (Timperio et al., 2003)	Adapt AAS
	International Physical Activity Questionnaire – Walking Section (van der Ploeg et al., 2010)	IPAQ-WS
	Short Questionnaire to Assess Health-enhancing physical activity (Wendel-Vos et al., 2003)	SQUASH
	European Prospective Investigation into Cancer and Nutrition Physical Activity Questionnaire (Cust et al., 2008)	EPIC PAQ
	13-Item Physical Activity Questionnaire (Nikolaidis & Säcklova, 2011)	13I-PAQ
	Adults and older adults (≥ 18 year old)	
	Nordic Physical Activity Questionnaire (Danquah et al., 2018)	NPAQ-short
	Self-report physical activity questionnaire (Visuthipanich et al., 2009)	SPAQ
	Transport and Physical Activity Questionnaire (Adams et al., 2014)	TPAQ
	General Practice Physical Activity Questionnaire (Ahmad et al., 2015)	GPPAQ
	Older Adults (≥ 65 year old)	
	Questionnaire d'Activité Physique pour les Personnes Âgées (de Souto Barreto, 2013)	QAPPA
	Incidental and Planned Exercise Questionnaire (Delbaere et al., 2010)	IPEQ
	Physical Activity Questionnaire for Elderly Japanese (Yasunaga et al., 2007)	PAQ-EJ
	The Longitudinal Ageing Study Amsterdam Physical Activity Questionnaire (Siebeling et al., 2012)	LAPAQ
Sleep +	Adults (18 to 64.9 years old)	
Sedentary Behaviour	SIT-Q (Lynch et al., 2014)	GAQ
Sedentary	Children (3 to 10 years old)	

Behaviour	GEMS Activity Questionnaire (Treuth et al., 2003)	
+ Physical	Children and adolescents (3 to 17.9 years old)	
Activity	Multimedia activity recall for children and adolescents (Ridley et al., 2006)	MARCA
	peas@tees(McLure et al., 2009)	
	Heart Smart Kids (Gance-Cleveland et al., 2018)	HSK
	Parental Questionnaire for Physical Activity and Sedentary Behaviour (Bringolf-Isler et al., 2012)	PQPASB
	Adolescents (11 to 17.9 years old)	
	ENERGY-child questionnaire (Singh et al., 2011)	ENERGY-C Q
	International Physical Activity Questionnaire (Rangul et al., 2008)	IPAQ
	School Health Action, Planning and Evaluation System physical activity questionnaire(Wong et al., 2006)	SHAPES
	Adults (18 to 64.9 years old)	
	Kaiser Physical Activity Survey (Ainsworth et al., 2000)	KPAS
	Sedentary, Transportation and Activity Questionnaire (Mensah et al., 2016)	STAQ
	International Physical Activity Questionnaire (Craig et al., 2003)	IPAQ
	Australian Women's Activity Survey (Fjeldsoe et al., 2009)	AWAS
	Workers' sitting- and walking-time questionnaire Time Method (Matsuo et al., 2016)	WSWQ- t-method
	Adults and older adults (≥ 18 year old)	
	Modified Version of the MONICA Optional Study on Physical Activity Questionnaire (Chau et al., 2012)	Modified MOSPA-Q
	Occupational Sitting and Physical Activity Questionnaire (Chau et al., 2012; Pedersen et al., 2016)	OSPAQ
	Rapid Assessment Disuse Index (Shuval et al.,	RADI

Sleep + Sedentary Behaviour + Physical Activity	2014)	
	Global Physical Activity Questionnaire (Bull et al., 2009)	GPAQ
	Older Adults (≥ 65 year old)	
	The Physical Activity Scale for the Elderly (Washburn et al., 1993)	PASE
	Community Health Activities Model Program for Seniors physical activity self-report questionnaire + transport items (Hekler et al., 2012)	CHAMPS+transport
	Community Healthy Activities Model Program for Seniors (Stewart et al., 2001)	CHAMPS
	Children and adolescents (3 to 17.9 years old)	
	Daughter Questionnaire (Ching & Dietz, 1995)	DQ
	Mother and Father Questionnaires (Ching & Dietz, 1995)	MaFQ
	Adults (18 to 64.9 years old)	
	Physical Activity Questionnaire (Norman et al., 2001)	PAQ
	Athens Physical Activity Questionnaire (Kavouras et al., 2016)	APAQ
	Sedentary Time and Activity Reporting Questionnaire (Csizmadia et al., 2014)	STAR-Q
	Question 8 of the Paffenbarger Physical Activity Questionnaire (Simpson et al., 2015)	Q 8 PPAQ
	EPIC-Norfolk Physical Activity Questionnaire (Wareham et al., 2003)	EPAQ2
	Workers' sitting- and walking-time questionnaire Percentage Method (Matsuo et al., 2016)	WSWQ - p-method
	Adults and older adults (≥ 18 year old)	
	New Questionnaire on Physical Activity (Pols et al., 1997)	NQPA
	Web-Based Physical Activity Questionnaire (Bonn et al., 2015)	Active-Q

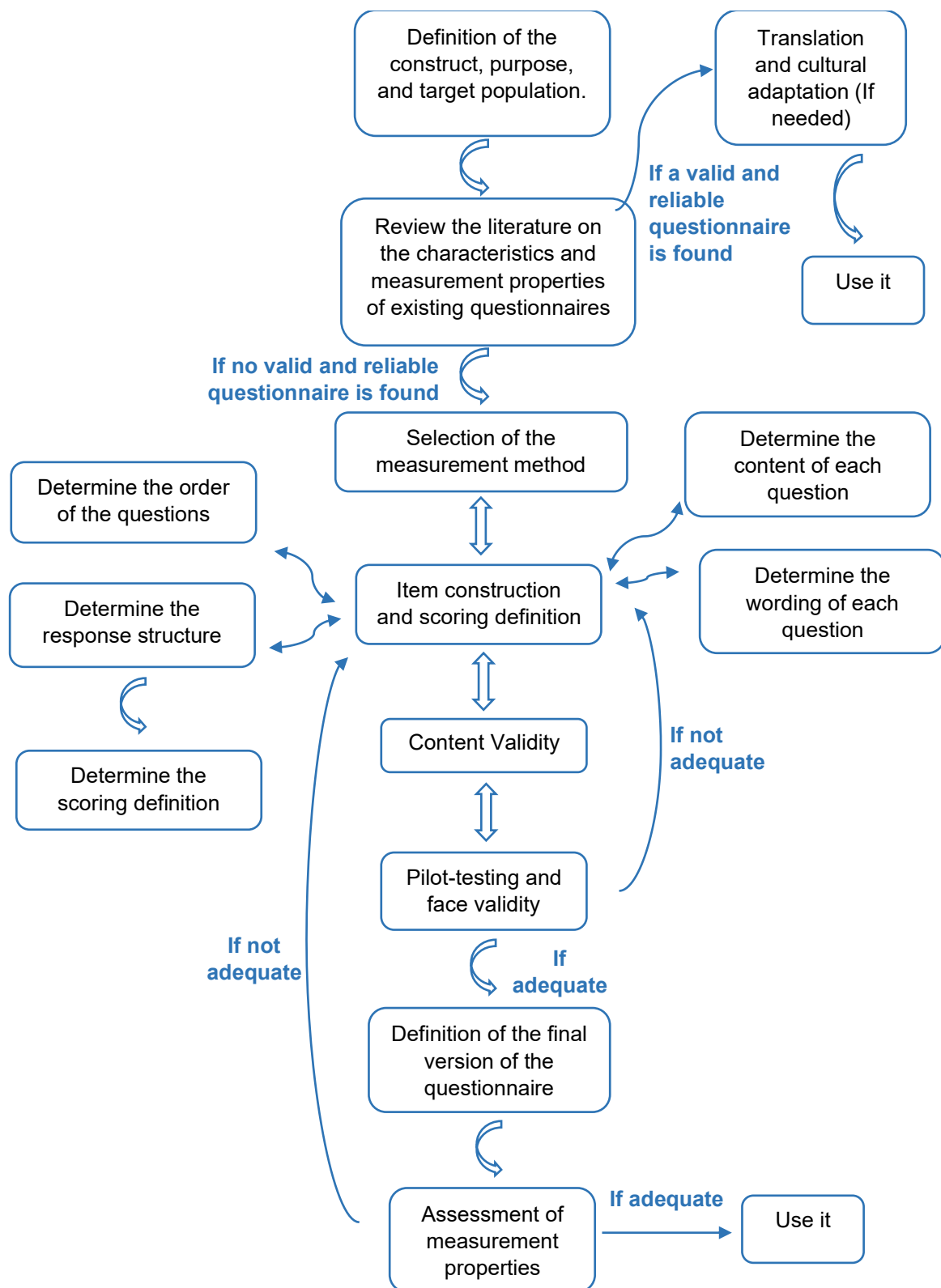
Although there are several questionnaires available to assess each movement behaviour or a combination of two or even three movement behaviours, a comprehensive review of existing questionnaires and their measurement properties is necessary for each age group. Such review is paramount to create an inventory of existing questionnaires, their characteristics, and psychometric properties. The inventory, informs the decision to adopt, adapt, translate, or develop *de novo* questionnaires to accurately assess movement behaviours in an integrated fashion. The existence of valid and reliable self-reported instruments to assess movement behaviours would significantly advance our understanding on population levels, patterns, and trends of movement behaviours.

3.1.2.1.1 Questionnaires development and validation procedures

Questionnaire development is a time-consuming and complex process because of the iterative nature of the process. Based on recent evidence on questionnaires development (De Vet et al., 2011; Patel & Joseph, 2016; Prinsen et al., 2018), the path to developing a questionnaire can be broke into several steps: 1) Definition and elaboration of the construct intended to be measured, the purpose and the target population (i.e., Identify the problem to address); 2) Review the literature on the characteristics and measurement properties of existing questionnaires on the topic; 3) Selection of the measurement method; 4) Item construction and scoring definition (e.g., determine content of each question; determine the response structure; define the wording for each question; establish the order of questions; define the outcome format); 5) Content validity; 6) Pilot-testing and face validity; 7) Definition of the final questionnaire; 8) Validation procedures. During the development of the questionnaire, researchers may have to go backwards and forwards through its development phases until they find the final version of the questionnaire. For example, if problems with item comprehension are identified after pilot testing,

the researchers should return to the item construction phase. The steps are presented in Figure 1.

Figure 1. Steps in the development and evaluation of a questionnaire



Adapted from: Measurement in medicine: a practical guide (De Vet et al., 2011); Questionnaire Designing Process: A Review (Patel & Joseph, 2016); and COSMIN guideline for systematic reviews of patient-reported outcome measures (Prinsen et al., 2018)

The first step (De Vet et al., 2011; Patel & Joseph, 2016; Prinsen et al., 2018) aims to address the questions ‘what do we want to measure?’ (construct, e.g., movement behaviours), in ‘which target population?’ (e.g., adults) and for ‘which purpose?’ (e.g., epidemiology, clinical research, etc.). In the definition of the construct researchers need to decide on the potential aspects of the construct to be measured. For example, if they pretend to measure sleep duration, sleep quality or both. Besides that, the questionnaire should be tailored to the target population, because this will help to define what kind of questions and how the questions are made. For example, children have more difficulty reporting past movement behaviours than adults due to their unstable patterns and cognitive immaturity (Baquet et al., 2007; Mattocks et al., 2007). In terms of measurement purposes, there are discriminative, predictive, and evaluative applications. Discriminative applications are used for diagnostic purposes, predictive applications are used to classify individuals according to their prognosis, and evaluative applications can measure effects such as, levels of movement behaviours and changes over time. The evaluative application is the most used for movement behaviour questionnaires. Besides that, the questionnaire should be developed according to whether its purpose is to define the effects of an intervention, or for large-scale or small-scale observational studies.

In the second step (De Vet et al., 2011; Patel & Joseph, 2016; Prinsen et al., 2018), conducting a review of similar questionnaires' qualitative characteristics and measurement properties is crucial. A systematic review serves to create an inventory of existing questionnaires to: 1) avoid creating a questionnaire that is redundant with other existing ones; 2) understand how the new questionnaire should be, by understanding the limitations of existing questionnaires, and 3) know if there is some questionnaire that can be translated or adapted to the researchers' specific needs. If a valid and reliable questionnaire for the target population is found during the review process, it can be translated (if necessary) and used. The translation process should consist of two phases: 1) Forward translation by two independent and different bilingual experts; and 2) Backward translation by other two independent bilingual experts

who are fluent in both languages. Also, sensitive questions may need to be reframed considering culture/contexts. If there is no need of translation, researchers will need to adapt an existing questionnaire or develop a new questionnaire that is appropriate for the purpose and targeted population.

Regarding the third step (De Vet et al., 2011; Patel & Joseph, 2016; Prinsen et al., 2018), researchers must determine the most appropriate measurement method for their intended purpose. This may involve deciding between a single-item or multi-item questionnaire. In this case, if researchers require a more detailed questionnaire such as one divided into domains, to inform future interventions, they should choose a multi-item questionnaire. However, if the aim is simply to determine, for example, the number of hours per week that people spend sitting in a given context, they may choose the single-item questionnaire.

Concerning the fourth step (De Vet et al., 2011; Patel & Joseph, 2016; Prinsen et al., 2018), once a preliminary list of questions has been compiled based on the review, it is important to analyse these questions. The content of each question should be discussed with experts in the field, answering to questions such as: “Is the question really necessary?”; “How would this question be used?”; “Do respondents have the information necessary to answer the question?”; “Is the question content biased or loaded in one direction?”; “Will the respondents give the information that is asked for?” (Patel & Joseph, 2016). Additionally, researchers should make sure that respondents understand the behaviour itself. For example, to report levels of SB, it is important that potential respondents understand the definition of SB and its practical aspects (e.g., sitting while eating is SB). The wording of each question should also be discussed. Questions should be clear, impartial, simple, and short, to avoid presenting a biased picture of the true situation. Additionally, questions should: be easily understood, focus on one idea at a time, and avoid using danger words, catchy words, jargons and words with emotional charged language (Patel & Joseph, 2016). Furthermore, the order of the questions is also an important matter to reflect upon. A well-structured order of questions can greatly decrease the likelihood of misreporting.

In the fourth step, another issue to consider is the response structure, which can be either open-ended or close-ended questions, and the scoring definition, which can be either continuous or categorical outcomes (De Vet et al., 2011; Patel & Joseph, 2016; Prinsen et al., 2018). Open-ended questions may lead to continuous outcomes (if the answer is a numeric value), and the respondent is required to come up with an answer himself. On the other hand, open-ended questions have the advantage of gathering insightful data and avoiding biased answers, particularly when asked for, context, ideas, opinions and feelings. However, respondents may struggle with knowing what to write, the length of the response, or how long to spend on the answer. A closed-ended question leads to a categorical outcome, and the questions provide several options of response (Patel & Joseph, 2016). A close-ended questions provide more structure, making them easier to analyze and interpret, but the options that are given may introduce bias, as respondents may choose a response that they would not typically consider (Patel & Joseph, 2016).

Regarding the scoring definition, in the case of a movement behaviour questionnaire its output variables can be either continuous or categorical (ordinal or nominal). Continuous scores allows for quantification and are expressed in numerical values (e.g., minutes or hours per day), while categorical scores involve ranking answers into a set number of groups (De Vet et al., 2011). The main advantage of continuous variables is that it can then be converted into a categorical variable *a posteriori*; whereas categorical values cannot be back transformed into continuous variables. For instance, having information on the number of minutes of MVPA is more informative than simply asking whether or not the participant meets the MVPA recommendation.

The fifth step aims to establish the content validity of the questionnaire, by conducting interviews and/or focus groups with experts in the field. Content validity is a qualitative evaluation defined by the degree to which the content of an instrument is an adequate reflection of the construct being measured (Mokkink et al., 2010). To assess the content validity, meetings with experts mainly aim to explore their insights on relevance (i.e., all questions in a questionnaire should be relevant for the construct of interest within a specific

population and context of use), comprehensiveness (i.e., all key aspects of the construct should be present) and comprehensibility (i.e., the questions should be understood by participants as intended) of the instructions, definitions and examples, items and response options, item wording, recall period, on the domains covered and the logic flow of the questionnaire (Prinsen et al., 2018; Willis, 2004). The meetings may be conducted using the Thinking Aloud Methodology and verbal probing (Jobe & Mingay, 1989; Patel & Joseph, 2016). In the Thinking Aloud Methodology, participants are invited to verbalise their thoughts while filling in the questionnaire, and verbal probing, involves detailed questioning about the perceived content and interpretation of the items. By the end of this step, the questionnaires may benefit from reformulations and adjustments based on the expert's input.

On the sixth step the questionnaire is piloted, and its face validity is assessed with potential end-users through interviews and/or focus groups. Face validity is the degree to which a questionnaire appears to be an appropriate reflection of the construct being measured. The pilot-test and face validity interviews and focus groups aim to understand the end-user's opinion on the easiness of completion and relevance, comprehensiveness and comprehensibility of the instructions, definitions and examples, items and response options, as well as item wording and recall period. These also aim to identify any misperceptions of the text that may lead to response errors and providing valuable insight into the ways respondents understand, retrieve, and formulate their responses (Patel & Joseph, 2016; Prinsen et al., 2018; Willis, 2004). As with experts, these meetings may be conducted using a Thinking Aloud Methodology and verbal probing (Jobe & Mingay, 1989; Patel & Joseph, 2016).

In the seventh step, the objective is to finalise the questionnaire for further validation. Therefore, some reformulations may occur based on end-users inputs. For example, if many individuals report not understanding a particular question, it may be due to its vagueness, complexity, or involves difficult answers. Therefore, it is necessary to reformulate such the question to overcome this limitation. (Patel & Joseph, 2016). The final version of the questionnaire should (De Vet et al., 2011): (1) be comprehensible to the

targeted population, independently of their education level; (2) do not have words with multiple meanings; (3) be specific; (4) do not have negative wording.

In the eighth step, once the questionnaire has been developed, it needs to be validated and the measurement properties need to be assessed. Evidence on measurement properties can be confusing due to the widespread variation in names and definitions, given to specific measurement properties. Frequently, many synonyms are used to identify the same measurement property. For example, the measurement property reliability is also mentioned as reproducibility, stability, repeatability, and precision (Prinsen et al., 2018). The main quantitative measurement properties that will be approached in this thesis will be: validity (i.e., criterion validity and convergent validity), and reliability (i.e., test-retest reliability) (Prinsen et al., 2018). Responsiveness, measurement error and limits of agreement (i.e., Bland-Altman) will be also approached. Other measurement properties are not relevant to this thesis because they are not useful to validate a questionnaire as a movement behaviour questionnaire. For example, the structural validity - the degree to which a questionnaires' scores accurately reflect the dimensionality of the construct being measured - is typically evaluated through factor analysis. This evaluation is particularly important when a questionnaire is based on a reflective model, where all items are a manifestation of the same underlying construct (Mokkink et al., 2010), which is not our case.

The broad definition of validity is 'the degree to which an instrument truly measures the construct(s) it proposes to measure' (Mokkink et al., 2010). Criterion validity refers to the correlation between a measure, and another measure considered to be a criterion or gold standard measure (e.g., questionnaire against accelerometer). Although there is no gold standard to measure all movement behaviours, the accelerometer was considered an appropriate criterion measure because it can accurately measure all movement behaviours simultaneously. This is widely used as a criterion comparison measure in validation studies of movement behaviours questionnaires (Migueles et al., 2017). For this case, the most commonly used statistics to assess the criterion validity are correlations (i.e., Spearman or Pearson) and

Bland-Altman analysis for continuous variables, as well as the percentage of agreement for categorical variables (Mokkink et al., 2010). Besides criterion validity, convergent validity is also commonly used to validate movement behaviours questionnaires. Convergent validity refers to the degree of agreement with another noncriterion measure that should assess the same behaviour parameter based on content validity (e.g., questionnaire against other questionnaire). This can be evaluated through the use of correlations (Spearman or Pearson) and Bland-Altman analysis for continuous variables, or the percentage of agreement for categorical variables (Mokkink et al., 2010).

Test-retest reliability refers to the consistency of test scores across multiple administrations under the same conditions, including researcher, timing, and preparation. The most commonly used statistics to evaluate the test-retest reliability are intraclass correlation coefficients (ICCs) for continuous variables, given that Pearson or Spearman correlation coefficients do not account for systematic errors (Armitage & Colton, 1998). For categorical variables, Cohen's kappa analysis is the most common statistic (Streiner et al., 2015).

Responsiveness refers to an instrument's ability to detect change over time in the construct being measured (Mokkink et al., 2010). It is a measure of the validity of a change score. Although evaluating questionnaire's responsiveness is paramount to understanding whether they are capable of measuring changes in movement behaviours over time (Terwee et al., 2010), there is a lack of responsiveness evaluation of the existing questionnaires measuring movement behaviours (Sattler et al., 2020; van Poppel et al., 2010).

Measurement error is reflected by how close the scores on repeated administrations are, expressed in the unit of the questionnaire (e.g., Limits of Agreement [LOA]). When evaluating measurement error in categorical variables, the percentage of agreement is commonly used as there are no units of measurement, only classification and ordering. The limits of agreement, proposed by Bland and Altman, are plots to assess agreements, in which systematic errors (between a questionnaire and an accelerometer or between

the first and second questionnaire application) can be seen (Bland & Altman, 1986).

Evidence suggests that the measurement properties of questionnaires assessing movement behaviours are typically inadequate. Sleep questionnaires, research has shown that the existing ones often inadequately report psychometric properties and seem to be primarily used for diagnostic purposes (Erwin & Bashore, 2017; Ibáñez et al., 2018; Spruyt & Gozal, 2011a, 2011b). According to a meta-analysis on sleep duration questionnaires, accelerometers were commonly used as the criterion measure for validation, and were found to have acceptable reliability (Nascimento-Ferreira et al., 2016).

Concerning SB questionnaires, several systematic reviews (Bakker et al., 2020; Dall et al., 2017; Hidding et al., 2017; Lubans et al., 2011) have concluded that the validity and reliability evidence for most questionnaires is of low quality. This is due to poor levels of agreement and accuracy, resulting in under and overestimation of total time spent in SB. Additionally, there is a wide methodological diversity between studies, and as a result, there is no conclusive recommendation for the best available questionnaire to measure SB. Overall, these reviews suggest that there is a scarcity of precise self-report instruments to measure PA and SB.

Several systematic reviews examining the measurement properties of PA questionnaires (Chinapaw et al., 2010; Helmerhorst et al., 2012; Hidding et al., 2018; van Poppel et al., 2010) have reported several methodological limitations and weak measurement properties, as well as a lack of studies reporting measurement error and content validity. These limitations were related to statistical methods and accelerometry data interpretation. To improve the methodological quality of the studies, it is recommended to increase the sample size, enhance statistical procedures and reporting methods, as well as to choose better comparison measures for validity studies (Chinapaw et al., 2010; Helmerhorst et al., 2012; Hidding et al., 2018; van Poppel et al., 2010).

3.1.2.2 Device-Based Measures

Various tools are available for assessing movement behaviours, each with its own advantages and disadvantages. The choice of tool depends on the objective and target of the assessment.

There are two main device-based measurement methods to assess sleep. Polysomnography is considered the gold standard of sleep measurement, incorporating various measures such as brain activity, muscle activation, eye movements, breathing patterns, oxygen saturation levels, and video recording (Sadeh, 2015). It is a valuable tool for evaluating sleep patterns and diagnosing sleep disorders, including sleep apnea, daytime sleepiness, and insomnia. However, this assessment tool is expensive, intrusive, and labour-intensive, making it impractical for home use (Kushida et al., 2005; Sadeh, 2015). Although less accurate than polysomnography, videosomnography is a method of recording sleep using video in a natural sleep environment. It can document specific child behaviours, such as parasomnias, and the involvement of caregivers. However, it requires home installation and later visual inspection and scoring, which can pose privacy issues and be time-consuming (Sadeh, 2015).

Regarding SB and PA, the global positioning system can be used to assess SB and PA. It is useful to understand the relationship between different contexts and active living, providing information on speed, elevation, and indoor-outdoor activities (Boudet et al., 2019; Katapally et al., 2020). However, it is not accurate to measuring SB during indoor activities (Boudet et al., 2019; Katapally et al., 2020).

The doubly labelled water method is used to measure total energy expenditure in free-living individuals over a period of 1 to 3 weeks. The principle of the doubly labelled water method relies on the difference in elimination rates between two stable isotopes, oxygen-18 and deuterium that were previously ingested. When combined with measurements of resting energy expenditure and the thermic effect of food, the doubly labelled water method can be used to calculate PA energy expenditure (Schoeller et al., 1986). This method is considered the gold standard measure for total daily energy expenditure in free-

living individuals. It entails low burden on participants and is unlikely to influence PA patterns. However, this method is expensive, as it requires technical equipment and trained personnel. Additionally, it requires measures of resting metabolic rate and thermic effect of food are required to calculate PA energy expenditure. It is not suitable for large-scale studies and cannot distinguish frequency, type, domains, and intensity of specific physical behaviours. Furthermore, it cannot differentiate between PA energy expenditure, basal metabolic rate, and diet-induced energy expenditure (Ainslie et al., 2003; Loprinzi & Cardinal, 2011; Park et al., 2014; Strath et al., 2013). Lastly, it is not an accurate measure of SB, although it can measure it (Tremblay et al., 2010).

Indirect calorimetry entails measuring the ventilatory volume, as well as the amounts of oxygen consumed, and carbon dioxide produced in a ventilated hood or respiration chamber (Ainslie et al., 2003; Strath et al., 2013). This method is a highly accurate and reliable measure of PA and energy expenditure, but it is not accurate for SB (Tremblay et al., 2010). This method is expensive, requires a high level of technical expertise, and is only suitable in short time assessments and small samples. Like doubly labelled water, it is unable to discriminate frequency, type, domains and intensity of specific physical behaviours (Ainslie et al., 2003; Loprinzi & Cardinal, 2011; Park et al., 2014; Strath et al., 2013).

Direct behavioural observation is another way to assess sleep, SB and PA. In the case of sleep, is mostly used to assess sleep in infants and requires trained observers who complete real time scoring of sleep and wakefulness states over a designated period of time at home or in nursery settings. This provides rich information on sleep and wakefulness states (Sadeh, 2015). For SB and PA, the direct observation consists of two trained specialists watching or video recording the participant during the timeframe of interest. They record all behaviours and categorize them according to a predetermined list (Aunger & Wagnild, 2020; McKenzie, 2002). This method is frequently used to study children's behaviours patterns, as other techniques, such as questionnaires and pedometers, are not adequate for this age group (McKenzie, 2002). This method does not require too much equipment or recall, and may be used to

describe with detail the context of the behaviour, distinguish the postures and have high validity and reliability (Aunger & Wagnild, 2020; McKenzie, 2002; Sadeh, 2015). However, is usually not done overnight and depends on intra- and inter-rater reliability. It requires extensive training and can modify the behaviour of the individual being assessed. Furthermore, it is not feasible for large-scale studies, and is inconvenient for the researchers and participants, as it is time-consuming and intrusive, respectively (Aunger & Wagnild, 2020; Sadeh, 2015; Strath et al., 2013). More recently, wearable cameras and photographic images have been used to classify contextual information about specific behaviours while in SB or PA, providing a relatively nonintrusive method of directly observing behaviour type and context (Chastin et al., 2013; Kang & Rowe, 2015; Kerr et al., 2013; Kim et al., 2015).

Pedometers are small sensors that typically use one of three internal mechanisms: a spring-suspended lever arm, a horizontal beam, or a piezoelectric crystal (Bassett, 2002). Pedometers are usually worn at the waist or thigh and are used to count steps, providing estimations of distance travelled (Bassett, 2002). The most advanced pedometers can also estimate time spent in different intensity classifications by using steps-per-minute thresholds (Marshall et al., 2009; Rowe et al., 2011). However, it is important to note that pedometers can only register walking and running activities and are not accurate measures of SB, although they can provide some indication of it (Tremblay et al., 2010).

Recently, several wearables such as wearable cameras, smartwatches, and smartphones have been commercially launched. These devices usually assess and provide output parameters for general PA, energy expenditure, posture, and body movement. They are small, unobtrusive and user-friendly (Holtermann et al., 2017). However, the algorithms used to generate these outcomes are not disclosed to users, precluding a deeper understanding of how outputs are generated.

Heart rate monitoring is a method that can be used to assess SB and PA. It utilises two different types of technology: the electrical signal (chest belt) and optical sensor (wristwatch or armband) (Shelley, 2007). The principle underlying

the use of heart rate derives from the physiological assumption that alterations in heart rate are indicative of cardiorespiratory stress during movement or non-movement behaviours (Livingstone, 1997). The sensors are affordable, inconspicuous, and reasonably comfortable. The measurement is based on individually calibrated thresholds that distinguish between rest and higher-intensity movement (using the flex-heart rate method). SB is estimated as daily time spent below the flex-HR threshold (Marconcin et al., 2021). However, this method is preferred for higher intensities and when context and type of PA are known, because at low-intensity levels the heart rate is also influenced by factors that cause sympathetic reactivity, and depends on the participant's age or fitness level (Livingstone, 1997).

Accelerometers are an alternative to heart rate monitors. Accelerometers were developed in the 1980's (Montoye et al., 1983), but only in early 2000' accelerometry became more accessible and its value for measuring PA increased (Troiano, 2005). Currently, accelerometers measure all movement behaviours and have higher memory storage and battery capacities, wider acceleration range, better linearity, smaller size, and with lower cost than several years ago (Troiano et al., 2014). Accelerometers captures accelerations of the body during movement. The can capture frequency, duration, and intensity of physical movement, in a time-stamped fashion (Troiano et al., 2014). Additionally, they can provide information on sleep–wake patterns for extended periods in the natural environment of the participant (Fekedulegn et al., 2020).

The mechanism behind accelerometers is that accelerative forces stress some transmitters (e.g., piezoelectric, piezoresistive, or capacitive sensors). This stress produces an electrical signal that is proportional to the magnitude of the acceleration force (Quante et al., 2015). Accelerometers can be uniaxial, biaxial, or triaxial. Uniaxial accelerometers are usually sensitive to movements in the vertical plane, while biaxial and triaxial accelerometers detect movement in the anteroposterior and/or lateral planes (Quante et al., 2015). The main data outcome from accelerometers is the body acceleration and deceleration. The raw accelerometer data is typically recorded in units of acceleration due to

gravity (g). These units are then converted, filtered, and summed, over a user-specified cycling period, known as an *epoch* and reported as counts. The resulting counts can be expressed as counts per second, counts per minute, or summed as total counts per day (Yang & Hsu, 2010). The conversion of acceleration units into counts using proprietary algorithms, the selection of various SB or PA cut-points and sleep algorithms, as well as the choice of different recording parameters (such as *epoch* length) can be problematic as different decisions can significantly alter the results. It is important to comprehend the impact of different methods for recording and converting data, as well as for using cut-points to classify movement behaviours, in order to accurately interpret accelerometer data. (Loprinzi et al., 2012).

Accelerometers can be attached to the body at the hip, ankle, wrist, or lower back. Typically, accelerometers attached at the hip with sensors more sensitive to vertical acceleration are used to record physical activity. This is because it allows for the detection of body's acceleration and deceleration during locomotion (Trost et al., 2005), while accelerometers worn at the wrist with sensors more horizontally oriented and sensitive to arms movement, are used for sleep measurement (Ancoli-Israel et al., 2003; Quante et al., 2015). On the other hand, most recent accelerometers also include an inclinometer that can distinguish between lying, sitting, and standing positions. Inclinometers (e.g., activPAL), provide data on absolute body positions (i.e., standing, sitting/lying, or sleep/no wear) and are mostly worn on the thigh. They can assess time spent in SB in two different ways: by posture, using tri-axial sensors that measure gravitational components or by spinal curvature, using three uni-axial gyroscopes that are orthogonally aligned (Boudet et al., 2019). In this sense, considering the definition of SB (Tremblay, Aubert, et al., 2017), posture monitors are better suited to measure SB than accelerometers. However, accelerometers also have limitations, and errors can be introduced at any stage of the analysis process. The limitations included the measurement of raw acceleration in the initial stages, the application of algorithms for preliminary processing, and the decision rules applied in the latter stages, such as determining what constitutes a valid day and week, which cut points to apply,

and what the minimum bout length criteria are (Kang & Rowe, 2015). Sleep duration, SB duration, and PA intensity ranges are classified using age-specific sleep algorithms and SB and PA cut-points, which are based on calibration studies (Migueles et al., 2017; Quante et al., 2015).

Multi-sensor monitors, combine accelerometers and physiological sensors attached to various points of the body. Heart rate monitoring and accelerometer measures have been combined using various analytical approaches: Accelerometer data can be used to distinguish between active and inactive periods of the day; the use of acceleration data at low and moderate levels of intensity and heart rate data at higher intensity levels; and differentiation between upper- and lower-body movement with the use of multiple accelerometers (Strath et al., 2013). These sensors (e.g., SenseWear, IDEEA, Actiheart) may be an interesting tool when compared with single sensing assessments. However, they are more expensive, burdensome, and are primarily used in clinical and validation studies, rather than in studies with large samples. Additionally, they require device technical expertise (Culhane et al., 2005). As such, there is limited evidence on the validity of these instruments under free-living conditions (Atkin et al., 2012; Sardinha & Judice, 2017).

3.1.2.2.1. The Use of Accelerometry to Assess 24-Hour Movement Behaviours

Device-based instruments such as, doubly labelled water, direct and indirect calorimetry, and direct observation of PA and SB, and polysomnography for sleep are usually used to individually measure Movement behaviours levels. However, these methods are unable to evaluate all three movement behaviours in an integrated fashion over a 24-hour period in free-living conditions, and each has its own limitations (Hills et al., 2014; Strath et al., 2013), as discussed in the previous section.

Because accelerometers, can detect data on body (non)movement (i.e., amount and intensities), continuously over extended periods of time in free living conditions, with relative ease of use and burden for researchers and study participants, as well as with high sensitivity for detecting changes in Movement

behaviours (Montoye et al., 2014; Welk, 2002), seem to be the most adequate device-based measure for synergistically measuring 24-hour movement behaviours (Burchartz et al., 2020). For example, accelerometry provides a wide range of outputs on Movement behaviours. These include sedentary time, light-intensity PA, moderate PA, vigorous PA, moderate-to-vigorous PA (MVPA), and total activity counts per day. Additionally, it can measure sleep-wake behaviours, such as sleep duration, nap duration, sleep latency, sleep maintenance efficiency, sleep fragmentation, sleep onset time, sleep offset time, and sleep midpoint (Bassett et al., 2015; Patel, Weng, et al., 2015). Furthermore, accelerometers are valid and reliable instruments (Pedišić & Bauman, 2015). They remove recall and response biases and may provide more consistent data across different population groups compared to questionnaires, which are influenced by language, literacy and recall/reporting biases (Pedišić & Bauman, 2015). However, single accelerometer-based methods are not able to measure the full spectrum of 24-hour movement behaviour activities. For instance, they cannot capture exercises that involve only the upper limbs, and do not provide metrics for muscle-strengthening and balance exercises, which are currently key components of the WHO (Bull et al., 2020) and 24-hour movement guidelines (Ross et al., 2020). Also, they have limited ability to quantify number of times spent in specific activities (Pedišić & Bauman, 2015). Therefore, the use of multiple accelerometers has the potential to capture most guideline components. However, this approach may be burdensome for participants and resource-intensive for large-scale studies. In this sense, questionnaires or diaries could be suitable complementary instruments to capture all the guideline components. Questionnaires or diaries can be useful for recording information about daily routines, specific activities such as muscle strength training and swimming, night-time sleeping patterns, naps, and non-wear time of accelerometers. However, the use of subjective measures may introduce biases due to recall, social desirability, and/or reporting of time in bed rather than sleep duration per se. These biases can compromise the value of accelerometry as a device-based measurement method (Boudebesse et al., 2013).

Accelerometry is often used as a device-based measure in observational and intervention studies. However, the data collection and processing methods used are dependent on researchers' individual decisions. This could lead to difficulties in making meaningful comparisons between studies if these decisions are not well reported and described (Pedišić & Bauman, 2015). In order for studies to be comparable, they must share similar methodological decisions. These include the type of accelerometer used, the selected *epoch* length, the number of days monitored, the criteria for valid days required, device placement, cut-points and algorithms applied, data reduction performed, and non-wear time criteria (Quante et al., 2015).

The lack of standardization limits the usefulness of these instruments for application across populations and studies, including for population-level surveillance of movement and behaviour (Pedišić & Bauman, 2015). Therefore, it is important to standardise methodological decisions using consensus guidelines for collecting and processing accelerometer data. Different methodological decisions for treating the same data can result in significantly different values for the same variables. This poses significant limitations, particularly in large-scale epidemiological studies, such as generalisability, validity, and sustainability, which are intended to be comparable (Pedišić & Bauman, 2015).

Finally, standardizing 24-hour accelerometry protocols for 24-hour Movement behaviour studies presents unique challenges. These include differentiating between sedentary behaviour, sleep, and non-wear time. It is also unclear whether a single 24-hour wrist- or hip-worn accelerometer can provide valid estimates for all movement behaviours. Additionally, determining the best body placement for the accelerometer remains a challenge (Pedišić, 2014).

3.1.3. Prevalence of Movement Behaviours

Over the past century, there has been a consistent decline in the duration of sleep among children and adolescents (Matricciani et al., 2017; Matricciani et al., 2012). More recently the WHO European Childhood Obesity Surveillance Initiative study, which included children aged 6 to 9 from 25 countries, showed

that 84.9% slept for 9 to 11 hours per night (Whiting et al., 2021). In a systematic review of actigraphy-derived sleep duration estimates for children and adolescents of different age groups, the pooled mean estimates for sleep duration were 9:68 hours for 3-5 years old, 8:98 hours for 6-8 year old, 8:85 hours for 9-11 years old, 8:05 hours for 12-14 years old, and 7:40 hours for 15-18 years old (Galland et al., 2018). A cross-sectional study of 165,793 adolescents, based on self-reported data, revealed an average sleep duration of 7:47 hours to 9:07 hours on school days and 9:31 hours to 10:22 hours on non-school days (Garipey et al., 2020). The Health Behaviour in School-aged Children study, conducted in Portugal revealed that 46.2% of school-aged children sleep for <8 hours on school days, while 55.8% sleep for >8 hours on weekends (Gaspar et al., 2022). In another study, the sleep duration of Portuguese children aged 2 to 10 ranged from 11:29 hours (in 2-year-old children) to 9:23 hours (in 10-year-old children) (Silva et al., 2013). Thus results indicate in toddlers the average amount of sleep over 24-hour periods is within the National Sleep Foundation's guideline of 11-14 hours of sleep per day (Hirshkowitz et al., 2015). On the other side, the school-aged children average sleep over 24-hour period is below the National Sleep Foundation's recommended guideline of 9-11 hours of sleep per day during week (Hirshkowitz et al., 2015), or the Canadian/Australian 24-hour movement guidelines.(Okely et al., 2017; Tremblay, Chaput, et al., 2017)

In the case of adults, a study with 730,187 participants across 63 countries showed that the average reported sleep duration was approximately 7 hours (Coutrot et al., 2022). This study's results align with those of a study conducted on 2,203,861 Americans (Sheehan et al., 2023). In Portugal, nearly half of adults report sleeping <6 hours per day, according to the Portuguese Society of Pneumology and the Portuguese Society of Labor Medicine (Sociedade Portuguesa de Pneumologia, 2019). This results indicate many adults do not attain the National Sleep Foundation's recommended guideline of 7-9 hours of sleep per day (Hirshkowitz et al., 2015), or the sleep component of the 24-hour movement guidelines of Canada (seven to nine hours of sleep per day) (Ross et al., 2020).

Regarding SB, a study conducted in 19 countries found that toddlers and preschoolers, aged 3 to 5 years, spent 56% (7.4 hours) of their waking time engaged in SB. (Kariippanon et al., 2022). A systematic review of accelerometry-measured SB revealed that toddlers spend an average of 5:37 hours per day in SB (Bruijns et al., 2020). Other systematic review on cross-European studies of SB found that children (aged 0-12 years) and adolescents (aged 13-18 years) spent between 3:12 hours, and 9:12 hours, or between 4:28 hours, and 8:26 hours, engaged in SB, respectively (Verloigne et al., 2016). Regarding screen time, a systematic review and meta-analysis found that only 24.7% of infants and toddlers (under 2 years old) adhered to the guideline of avoiding screen time, while 35.6% of toddlers and preschoolers (2 to 5 years old) adhered to the guideline of no more than 1 hour of screen time per day (McArthur et al., 2022). Other study, showed that 79.4% of the children at 2 years old and 94.7% at 3 years old, also do not meet screen time guidelines (Madigan et al., 2020). A study conducted by the WHO European Childhood Obesity Surveillance Initiative included children aged 6 to 9 years, from 25 countries, showed that 60.2% of the children engaged in screen time for <2 hours per day (Whiting et al., 2021). A systematic review and meta-analysis on the prevalence of objectively measured SB in children aged 1-5.99 years, showed that this age-group spent 51.4% of their waking time in SB (Pereira et al., 2019). A scoping review of surveillance studies in children and adolescents aged 5 to 18 years showed that this age group spends an average of 3.6 hours per day (ranging from 1.3 to 7.9 hours per day) engaged in screen time (Thomas et al., 2020). The Portuguese Health Behaviour in School-aged Children study showed that the percentage of children (11 to 15 years old), with <2 hours of recreational screen time, ranged between 35% for TV, 68% for video gaming and 58% for computer use (Dos Santos et al., 2020) showing that the prevalent screen-time behaviour in children that comply with the guidelines of screen time, is playing video games.

When looking at the prevalence of SB in adults, a recent systematic review of worldwide surveillance of self-reported SB in adults included data from 62 countries, showed that adults spent a median of mean of 4.7 hours per day

in SB (McLaughlin et al., 2020). According to the 2022 Eurobarometer, 79% of participants reported spending >2:30 h/day on SB (European Commission, 2022). A systematic review on the prevalence of SB in older adults, showed that 60% reported sitting for more than 4 hours per day (Harvey et al., 2013). However, it is difficult to discuss this data as the WHO guidelines for SB do not specify the maximum number of hours that older adults should spend in SB, and the Canadian 24-hour movement guidelines recommend spending less than 8 hours per day in SB.

In relation to PA, a systematic review of accelerometry-measured PA showed that, on average, toddlers engaged in ~250 min/day of total PA, ~190 min/day of light PA, and ~60 min/day of MVPA (Bruijns et al., 2020). Globally, 81% of adolescents engage in less than one hour of MVPA (Guthold et al., 2020): i.e., do not attain recommended PA guidelines. The WHO's Global Status Report on Physical Activity for Portugal shows that, approximately 78% of boys and 91% of girls engage in <1 h/day of MVPA (World Health Organization, 2022). In addition, 44.3% of individuals performed PA <3/week (Gaspar et al., 2022). According to a study on levels of accelerometer-measured PA, 15.4% of Portuguese adolescents met the recommended levels of PA (Magalhães et al., 2023). Globally, 27.5 % of adults do not meet the WHO recommendations for PA (Guthold et al., 2018). In Portugal, according to the 2022 Eurobarometer (European Commission, 2022) and the EUPASMOS project (European Union Physical Activity and Sport Monitoring System) (Vähä-Ypyä, 2022), 78% and 39%, respectively, reported never or rarely practicing exercise or sport. During the COVID-19 pandemic, the Portuguese General-health Directorate carried out a national survey on the eating and PA behaviour of the Portuguese in a context of social restraint, the REACT-COVID (Silva et al., 2021). During the first wave of the pandemic, 46% of 6,000 Portuguese surveyed reported adequate levels of PA. After the lockdown, this number increased to 54.3% out of 5,000 Portuguese surveyed (PNPAF & PNPAS, 2021). Other study with 6,369 Portuguese, using accelerometry and a sample of 6,369 participants, found that 71.2% adults and 30.6% of older adults met the PA recommendations (Magalhães et al., 2023).

Regarding the prevalence of meeting 24-hour movement guidelines, a systematic review and meta-analysis comprising 387,437 preschoolers and adolescents in 23 countries revealed altogether that only 7.12% met all three 24-hour movement guidelines and that 19.21% do not attain a single guideline. When analysed by age group, compliance with the three guidelines was 11.26% in preschoolers, 10.31% in children, and 2.68% in adolescents. Additionally, 8.8%, 15.6%, and 28.59% in preschoolers, children, and adolescents, respectively, did not meet any of the guidelines (Tapia-Serrano et al., 2022). In Portugal, a study of 739 preschoolers measured with accelerometry (Vale & Mota, 2020), found that 80.6%, 28.6% and 20.3% met the guidelines for sleep, PA and screen time guidelines, respectively. In addition, 52.8% met only one guideline, 31.7% met at least 2 of the guidelines, 4.5% met the three guidelines and 11.1% did not meet any of the three guidelines.

In adults data is less abundant. In the United States National Health and Nutrition Examination Survey (NHANES), which included 9,927 participants, showed that 23.7% met the 24-hour physical activity guidelines (Kindratt et al., 2023). No study was found with a multi-country sample that assessed adherence to the 24-hour movement guidelines in adults.

3.1.3.1. Movement Behaviours' Monitoring and Surveillance Systems

The changes of the recommendations, such as the removal of the 10-minute bout requirement, the change in youth recommendations from recommending at least 60 min per day to recommending at least an average of 60 min per day, the inclusion of balance activities for the elderly, and the integration of all Movement behaviours (i.e. sleep, SB and PA) into the recommendations, promote thoughtful and substantial changes to current standardised tools and monitoring systems (Troiano et al., 2020).

Surveillance is a critical component of public health planning and practice because it provides ongoing, systematic collection, analysis, and interpretation of outcome-related data for use in planning, implementing, and evaluating public health interventions (Sallis & Pate, 2021). Monitoring and surveillance systems play a central role in epidemiological research. The primary function of

these systems is to inform policymakers and other public health stakeholders about the prevalence of movement behaviours in populations, trends over time, and their association with health outcomes. Additionally, they evaluate the effectiveness of health-related policy interventions. In addition, and given the impact of movement behaviours on health, PA epidemiologists should advocate for the integration of appropriate measurement of movement behaviours variables into national health surveillance systems; for example, linkage with medical records of morbidity and mortality. However, PA has been included in health surveillance systems much later than other risk factors (e.g. tobacco use), probably because of the complexity of assessing PA and/or because WHO only launched the first global policy on PA in 2004 (WHO, 2004) and the first global guidelines on PA in 2010 (WHO, 2010).

Globally, mainly in highly developed countries (Hallal et al., 2012), there are several movement behaviours monitoring and surveillance systems. A study found six multinational surveillance systems and 38 national surveillance systems (Bel-Serrat et al., 2017). The Behavioural Risk Factor Surveillance System (BRFSS), the Youth Risk Behaviour Survey (YRBS), the US National Health and Nutrition Examination Survey (NHANES), the Australian Health Survey (AHS), the Healthy Behavior in School Children (HBSC), the Health Survey for England (HSE) and the European Health Interview Survey (EHIS), which repeatedly assess the levels movement behaviours (mainly PA and SB), are good examples. Data are mostly based on existing questionnaires such as the International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003). However, there are some problems with this questionnaire in terms of its suitability for new formats of recommendations. However, while there is room for internal improvement (Sallis & Pate, 2021), ideally all national surveillance systems should be comparable in terms of the instruments and methodologies used in order to have comparable data across countries. The usefulness of these systems could be improved by attempting to harmonise the data collection and processing protocols of different studies from different countries, ensuring that the same relevant health-related components of movement behaviours are collected in different countries. Additionally, to get a better idea

of the levels of movement behaviour at a global level, having this type of surveillance system in place should not be limited to developed countries; in this sense, initiatives such as the WHO's STEPwise are essential. The WHO STEPwise approach to chronic disease risk factor surveillance aims to help developing countries obtain information on risk factors for major noncommunicable diseases. The goal is to build and strengthen country capacity (Hallal et al., 2012) to undertake surveillance within an integrated, systematic and sustainable framework.

Regarding the data collection methods, movement behaviours surveillance currently relies mostly on self-reported questionnaires which have several advantages (e.g., able to identify types of PA) and limitations (e.g., measurement bias) (Fulton et al., 2016). Another solution has been to complement self-reported data with accelerometers in a sub-group (e.g., In NHANES), but the high cost, low feasibility and the number of existing data collection and management protocols, make this strategy challenging (Ainsworth & Macera, 2012; Pedišić & Bauman, 2015). As an alternative, it has been considered the use of wearables, given its role on behaviour change and its increasing consumption (Patel, Asch, et al., 2015). However, we must be careful when using these devices in epidemiological studies, as these data sources seem to produce biased estimates due to the number of different devices that exist, because of the characteristics of wearables users, who are typically more active than the general population (only 5% of the world's population uses these devices) (Omura et al., 2017; Statista, 2020). Moreover, wearable device manufacturers may not be interested in sharing data with public health surveillance, because this would imply disclosure of algorithms and most likely require validation studies. In this sense, the modification of self-report instruments for surveillance is the priority (Troiano et al., 2020).

Comparability of data over time and between countries is important. However, in a context where the guidelines are changing, there is also a need to change the way movement behaviours are monitored, either in terms of the instrument and data analysis used, or the reporting methods (Troiano et al., 2020). The emergence of the 24-hour movement behaviour paradigm and new

guidelines could be a catalyst for the development of new harmonised 24-hour movement behaviour surveillance systems to provide a mechanism for regular assessment and to obtain comparable data across countries and to align their policies, action plans and recommendations to address inadequate movement behaviours levels and types. Therefore, changes in surveillance systems, instruments and indicators need to be superimposed on a willingness to have stable instruments that support the tracking of population compliance with the guidelines (Troiano et al., 2020). For such endeavour, validated self-report instruments (e.g. questionnaires) that are better adapted to the new reality of recommendations (e.g. covering the three behaviours) and a consensus on how to collect and manage data from device-based instruments (e.g. accelerometers) that can be integrated in future continuous monitoring and surveillance systems of 24-hour movement behaviour are paramount.

3.1.4. Physical activity guidelines

The increase in human life expectancy over the past two centuries is a remarkable achievement of modern civilization (Oeppen & Vaupel, 2002; Vaupel, 2010). As people live longer, it is important to develop and promote strategies that increase the number of years spent in good health (Robine et al., 2009). In this context, movement behaviours have gained recognition due to their health-related associations, throughout the life course.

In the past, PA was necessary, for activities such as food gathering, hunting and escaping predators. However, with the advent of sedentariness and then with industrialization, PA is no longer a requirement for survival (Eaton & Eaton III, 2003). In the last century, people have begun to have easy access to highly processed, obesogenic foods and less physically demanding jobs, having therefore, less need for PA to meet their daily basic needs.

Over the past century, western countries have gone through an epidemiological transition, and in modern societies, chronic noninfectious diseases have become the dominant causes of morbidity and mortality (Habib & Saha, 2010). This raised the need to develop public health strategies to increase PA levels (e.g., public health guidelines), as there is a strong link

between non-communicable diseases and physical inactivity (Katzmarzyk et al., 2022).

Over the past decades, PA guidelines have evolved from a one-dimensional perspective (i.e., just aerobic exercise) and fitness-oriented to more integrated (i.e., Sleep, SB and PA) and public health-oriented guidelines (Ding, Mutrie, et al., 2020).

In 1975, the American College of Sports Medicine (ACSM) released the first exercise guidelines, which focused on improving aerobic fitness of healthy adults (ACSM, 1978). The ACSM 1975 guidelines suggested that healthy adults should engage in 15 to 60 minutes of aerobic exercise, 3 to 5 days per week, at 50 to 65% of their heart rate reserve to improve and maintain fitness (ACSM, 1978).

With the growing body of evidence on the health associations with PA, namely the MVPA (e.g., walking), the guidelines shifted from an exercise perspective (i.e., fitness-oriented) to a PA perspective (i.e., public health-oriented) (Pate et al., 1995). These new PA guidelines, released in 1995 by the ACSM and the Centers for Disease Control and Prevention, advocated that, adults should accumulate 30 minutes or more of moderate-intensity aerobic activity, on most, preferably all, days of the week (Pate et al., 1995). However, this recommendation of “on most, preferably all, days of the week” was considered vague and misunderstood by a large part of the population and was therefore later changed to at least 5 days a week (Haskell et al., 2007).

Until 1998, the PA guidelines for youth were similar to those for adults (ACSM, 1988; National Institutes of Health, 1996; Sallis & Patrick, 1994). In 1998, the first set of guidelines based on studies of children and youth was developed (Biddle et al., 1998). In these guidelines, the UK Health Education Authority recommended that youth should engage in at least 60 minutes of moderate-intensity PA daily (Biddle et al., 1998). Since then, the PA guidelines for children have mostly remained consistent in terms of the recommended volume of PA (Janssen, 2007), culminating in the 2005 United States of America’s PA guidelines for children, suggesting that children aged 6-18 years

should engage in at least 60 minutes per day of MVPA, based on a review of the literature on the health-related benefits of PA (Strong et al., 2005).

In 2007 the ACSM and the American Heart Association, launched updated PA guidelines for adults (Haskell et al., 2007). According to these guidelines, adults should engage in moderate-intensity aerobic PA for at least 30 minutes on five days each week or vigorous-intensity aerobic activity for at least 20 minutes on three days each week, or a combination of moderate- and vigorous-intensity activity (Haskell et al., 2007). These guidelines clarified that only activities of moderate- or vigorous-intensity, performed in bouts of at least 10 minutes, can be counted for the guidelines. Therefore, routine activities of daily living that are of light intensity or last less than 10 minutes do not count for the guidelines (Haskell et al., 2007). In addition, for the first time, guidelines were made for muscle-strengthening activities. Therefore, alongside aerobic activity, adults should perform exercises that maintain or increase muscular strength and endurance on at least two days per week. To comply with this recommendation, it is suggested that 8-10 exercises be performed on two or more non-consecutive days per week, using the major muscle groups (Haskell et al., 2007). The recommended approach was to perform eight to 12 repetitions of each exercise until volitional fatigue is reached. Finally, these guidelines acknowledged for the first time that exceeding the minimum recommended amounts, can provide additional health benefits and improve physical fitness levels (Haskell et al., 2007).

In accordance with the latest PA guidelines, the Center for Disease Control and Prevention and the WHO released new guidelines in 2008 (Fulton & Kohl, 2008) and 2010 (WHO, 2010) respectively, directed at all age groups aged five years and above. In these documents, it is recommended that children and adolescents (aged 5 to 17 years) engage in at least 60 minutes of PA per day. The majority of this time should be spent in aerobic MVPA, including at least three days a week of vigorous-intensity activities. In addition, it is recommended that children and adolescents engage in muscle-strengthening and bone-strengthening activities for at least three days per week. (Fulton & Kohl, 2008; WHO, 2010). For adults (aged 18 to 64 years), it is recommended

to engage in at least 150 minutes of moderate-intensity aerobic PA, or at least 75 minutes of vigorous-intensity aerobic PA, or a combination of both, along with at least two days of muscle-strengthening activities, stating that 'Some activity is better than none' (Fulton & Kohl, 2008; WHO, 2010). This last statement was a paradigm-changer and represented new evidence pointing out that any type and amount of PA is beneficial. Furthermore, to achieve additional health benefits, adults should engage in more than 150 minutes of moderate-intensity or more than 75 minutes of vigorous-intensity aerobic PA per week, or a combination of both intensities (Fulton & Kohl, 2008; WHO, 2010).

The PA guidelines for older adults are the same as those for adults, with some additional guidelines. When older people are unable to perform the recommended amount of PA for adults due to a chronic condition, they should engage in as much PA as they are able to. Additionally, if they are at risk of falling, they should perform exercises that target balance. It is important for older people to determine their level of effort for PA relative to their physical condition, and to understand if their chronic conditions affect their ability to safely engage in PA. (Fulton & Kohl, 2008; WHO, 2010).

Between 2010 and 2013, Australia (Australia Government, 2010), United Kingdom (Physical Activity Health Improvement and Protection, 2011) and Canada (Tremblay et al., 2012), launched their guidelines to increase PA and reduce SB in early years (i.e., 0 to 5 years old). The general recommendation for PA was to encourage supervised floor-based play from birth and engage in three hours per day of PA (Australia Government, 2010; Physical Activity Health Improvement and Protection, 2011; Tremblay et al., 2012). Regarding screen time, the general recommendation for children under two years old was to avoid screen time (Australia Government, 2010; Physical Activity Health Improvement and Protection, 2011; Tremblay et al., 2012). In Australia (Australia Government, 2010) and United Kingdom (Physical Activity Health Improvement and Protection, 2011), for children aged 3-5 years, the recommendation was less than one hour of TV or electronic media per day, and limit the amount of total entertainment screen time to one to two hours per day. In Canada (Tremblay et al., 2012), the recommended screen time for children aged 2-4

years was less than one hour. Regarding non-screen time, Australia recommended performing sedentary activities for less than one hour at a time, except for sleeping (Australia Government, 2010); The United Kingdom recommends minimizing the amount of time spent being sedentary for extended periods, except for time spent sleeping (Physical Activity Health Improvement and Protection, 2011); and Canada recommended minimizing time spent being sedentary during waking hours, including prolonged sitting or being restrained for more than one hour at a time (Tremblay et al., 2012).

In 2018, the United States Department of Health and Human Services, launched the Physical Activity Guidelines for Americans, second edition (Piercy et al., 2018). These guidelines were specific for each age-group (preschoolers, children and adolescents, adults and older adults). The guidelines for preschoolers (i.e., 3 to 5 years old) informed that they should be physically active throughout the day to promote growth and development. The guidelines for children and adolescents have remained unchanged since the last edition. However, the guidelines for adults have been updated to recommend that adults should engage in 150 to 300 minutes per week of moderate-intensity aerobic PA, or 75 to 150 minutes per week of vigorous-intensity aerobic PA, or an equivalent combination of both intensities per week. Additionally, adults should perform strengthening activities of moderate or greater intensity involving all major muscle groups on at least two days per week. To obtain further health benefits, adults should engage in more than 300 minutes of moderate-intensity aerobic PA. The guidelines for older adults were the same as for adults, but with the same additions of the last published guidelines. Moreover, due to the increase in research on SB, the recommendation to reduce SB has been simplified to 'Move more and sit less' (Piercy et al., 2018). The inclusion of sedentary behaviour in the guidelines is significant because, as well as being an independent risk factor for health (Chau et al., 2015), it is a distinct concept from physical inactivity, which is defined as an insufficient level of PA to meet the recommended guidelines (Tremblay, Aubert, et al., 2017). For instance, an individual may be considered active, achieving adequate levels of MVPA, while still exhibiting high levels of SB.

Recently, there has been a shift in the approach to guidelines due to advances in statistical analysis and evidence. This involves developing guidelines for the three existing movement behaviours (sleep, SB, and PA), as outlined in the 24-hour movement guidelines. The criteria used to classify time into these behaviours are wakefulness (i.e. awake/not awake), posture (i.e. lying/sitting/standing), and relative energy expenditure (≤ 1.5 METs or >1.5 METs) (Pedišić et al., 2017). Canada was the first country to develop guidelines based on this paradigm (Tremblay et al., 2016). The first 24-hour movement guidelines were launched for Canadian children and adolescents (aged 5-17 years) and stated that this age group should perform: uninterrupted 9-11 hours of sleep per night for those aged 5-13 years and, 8-10 hours per night for those aged 14-17 years, with consistent bed and wake-up times; an accumulation of at least 60 minute per day of MVPA involving a diversity of aerobic activities, and vigorous PA and muscle/bone strengthening activities should be incorporated at least 3 days per week; several hours of a diversity of structured and unstructured light PA; no more than two hours per day of recreational screen time; and limited sitting for long periods. These were the first guidelines to include sleep as a movement behaviour. Prior to this inclusion, sleep guidelines were primarily produced by the National Sleep Foundation. They recommends 14 to 17 hours for newborns, 12 to 15 hours for infants, 11 to 14 hours for toddlers, 10 to 13 hours for preschoolers, nine to 11 hours for school-aged children, eight to 10 hours for teenagers, seven to nine hours for young adults and adults, and seven to eight hours for older adults of sleep per day (Hirshkowitz et al., 2015).

In 2017, Australia (Okely et al., 2017) and Canada (Tremblay, Chaput, et al., 2017) launched their 24-hour Movement Guidelines for children aged 0-5 and 0-4 years, respectively. The guidelines in both countries were similar, with only a few differences in their written presentation due to cultural variances. Infants (aged <1 year old for both countries) should be physically active several times in various ways, particularly through interactive floor-based play; more PA is better. For infants who are not yet mobile, the guideline was at least 30 minutes of tummy time spread throughout the day while awake. Regarding SB,

infants should not be restrained for > 1 hour at a time. Screen time was not recommended. When in sedentary time, engaging in activities such as reading and storytelling with a caregiver was encouraged. For sleep, the guideline for infants was 14–17 hours/day (for those aged 0–3 months) or 12–16 hours/day (for those aged 4–11 months) of good-quality sleep, including naps (Okely et al., 2017; Tremblay, Chaput, et al., 2017). Toddlers (aged 1-2 years old for both countries) should spend at least 180 minutes in diverse PA of all intensities, including energetic play, spread throughout the day; more PA is better. Regarding SB, toddlers should not be restrained for more than 1 hour at a time or sitting for long periods. For toddlers younger than two years, sedentary screen time was not recommended. For those aged two years, sedentary screen time should be no more than 1 hour; less screen time is better. When in sedentary time, engaging in activities such as reading and storytelling with a caregiver is encouraged. For sleep, the guidelines for toddlers was 11–14 hours of good-quality sleep, including naps, with consistent bedtimes and wake-up times (Okely et al., 2017; Tremblay, Chaput, et al., 2017). Finally, preschoolers (aged 3-5 years for Australia and 3-4 years for Canada) should spend at least 180 minutes in various PA spread throughout the day, of which at least 60 minutes in energetic play; more PA is better. Regarding SB, the guideline was do not be restrained for more than 1 hour at a time or sitting for long periods. Sedentary screen time should be no more than 1 hour; less screen time is better. When in sedentary time, engaging in activities such as reading and storytelling with a caregiver is encouraged. The guideline for sleep was 10–13 hours/day of good-quality sleep, which may include a nap, with consistent bedtimes and wake-up times (Okely et al., 2017; Tremblay, Chaput, et al., 2017).

In 2019, based on the Canadian and Australian guidelines for the early years, the World Health Organization (WHO) launched 24-hour movement guidelines for children under 5 years old (WHO, 2019b). According to these guidelines, it is recommended that infants, engage in PA multiple times a day in various ways. This can be achieved through interactive floor-based play or at least 30 minutes of prone position throughout the day while awake for infants who are not yet

mobile. In relation to SB, it is recommended that infants should not be restrained for more than one hour at a time. Screen time is not advised, and time spent in SB should be dedicated to activities such as reading and storytelling with a caregiver. With regards to sleep, it is recommended that infants aged 0-3 months and 4-11 months should have 14-17 hours and 12-16 hours/day of good quality sleep per day (including naps and night time sleep), respectively (WHO, 2019b). Toddlers aged 1-2 years should engage in PA of any intensity, including MVPA, for a minimum of 180 minutes per day. It is recommended that toddlers do not remain restrained for more than one hour at a time or sit for extended periods of time. During sedentary time, toddlers should engage in activities such as reading and storytelling with a caregiver. For one-year-old toddlers, it is not recommended to have sedentary screen time. For two-year-old toddlers, sedentary screen time should be limited to less than one hour. In terms of sleep, toddlers should aim for 11 to 14 hours of good quality sleep per day (including naps and night time sleep), (WHO, 2019b). Preschoolers aged 3-4 should engage in a minimum of 180 minutes of PA of any intensity, including at least 60 minutes of MVPA, over the day. Preschoolers should not be restrained for more than one hour at a time or sit for extended periods of time. While being sedentary, preschoolers should engage in activities such as reading and storytelling with a caregiver. Sedentary screen time should be limited to less than one hour. Preschoolers should aim for 10-13 hours of good quality sleep per day (including naps and night time sleep) (WHO, 2019b). For all ages, for additional health benefits, children should meet all the guidelines for PA, SB and sleep in a 24-hour period (WHO, 2019b).

Besides Australia and Canada, several countries are also launching their 24-hour movement guidelines for different age groups. For example, New Zealand (Ministry of Health New Zealand, 2021) has launched guidelines for children (5–12 years) and young people (13–17 years) and South Africa has launched for early years (birth to 5 years) (Draper et al., 2020). Besides that, 24-hour movement guidelines for all age groups were launched in Croatia (Jurakić & Pedišić, 2019), Finland (UKK Institute, 2022), and Thailand (Thailand Ministry of Public Health, 2017). Australia and Canada also continued their

efforts, and recently released 24-hour movement guidelines for Australian children and adolescents (5-17 years) (Okely et al., 2022), as well as for Canadian adults and older adults (Ross et al., 2020)

The 24-hour movement guidelines were developed based on studies that recognise the integrative approach to all movement behaviours and their health-related associations. As an example of these guidelines, Canada recommends that adults perform a variety of types and intensities, such as at least 150 minutes per week of aerobic MVPA, at least twice a week of muscle strengthening activities using major muscle groups, and several hours of light PA, including standing (Ross et al., 2020). Sedentary time should be limited to 8 hours or less, including no more than 3 hours of recreational screen time, and breaking up long periods of sitting as often as possible. It is also recommended to get 7 to 9 hours of good-quality sleep on a regular basis, with consistent bed and wake-up times (Ross et al., 2020).

Based on Canadian 24-hour movement guidelines (Ross et al., 2020) as well as on the United States guidelines for PA and SB (Piercy et al., 2018), in 2020, the WHO launched new guidelines on PA and health (Bull et al., 2020). The guidelines highlight the positive relationship between PA and health, including the benefits of any duration of PA, even at light intensity, and the benefits of replacing SB with PA (Chastin et al., 2019; Ding, Varela, et al., 2020). These were specific to children and adolescents, adults, older adults, people with disabilities and chronic conditions, and pregnant women. Generally, these guidelines were similar to the guidelines launched by the United States Department of Health and Human Services in 2018 (Piercy et al., 2018). The general recommendation for children and adolescents is to engage in an average of 60 minutes of aerobic MVPA per day, including at least three days of vigorous-intensity aerobic activities, as well as muscle and bone-strengthening activities. It is also recommended for children and adolescents to limit SB and screen time. For adults, the guideline advocates that adults should perform 150 to 300 minutes of moderate intensity aerobic PA, or 75 to 150 minutes of vigorous intensity aerobic PA, or equivalent combination of both intensities per week; two days of strengthening activities; and reduce the sedentary time,

replacing it with light PA or a more intense activity. Adults should perform more than 300 minutes of moderate intensity aerobic PA or more than 150 minutes of vigorous intensity aerobic PA, or an equivalent combination of both intensities to get additional health benefits. Additionally, the guideline recommends limiting SB and replacing it with PA of any intensity. For older adults, the guidelines are the same as for adults. However, WHO maintained the additions reported in previous guidelines for older adults. Additionally, it is recommended that older adults engage in diverse multicomponent PA at least three days per week, with an emphasis on functional balance and strength training at moderate or greater intensity (Bull et al., 2020). One important change in these new guidelines is that any bout of PA, regardless of its length, is considered beneficial, not just bouts of ≥ 10 minutes, as in previous guidelines. This change could help to promote the public health message (Segar et al., 2020). The overall message of these guidelines is that any PA, no matter how short in duration, is better than doing nothing at all (i.e. Every move counts) (Bull et al., 2020). This message includes, for the first time, a recommendation for light-intensity PA, which is a significant advancement considering the latest evidence on its role in promoting health (Chastin et al., 2019; Fuezeki et al., 2017).

Since late 2019, Portugal has been developing 24-hour Movement Behaviour guidelines for all age groups. This dissertation is framed within the context of this project, as our research group is developing a knowledge translation plan to disseminate the guidelines and create adapted instruments to measure them in an integrated way.

Chapter 4

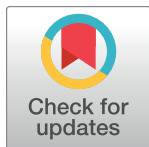
4.1. Study 1 (Paper I) – Questionnaires measuring movement behaviours in adults and older adults: Content description and measurement properties. A systematic review

(Published)

RESEARCH ARTICLE

Questionnaires measuring movement behaviours in adults and older adults: Content description and measurement properties. A systematic review

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Abstract

Background

Sleep, sedentary behaviour and physical activity are constituent parts of a 24h period and there are several questionnaires to measure these movement behaviours, the objective was to systematically review the literature on content and measurement properties of self- and proxy-reported questionnaires measuring movement behaviours in adults and older adults.

Methods

The databases PubMed, CINAHL, PsycINFO and SPORTDiscus were systematically searched until April 2021. Articles were included if: the questionnaires were design for adults and older adults; the sample size for validity studies had at least 50 participants; at least, both validity and test-retest reliability results of questionnaire that were developed specifically to measure the amount of sleep, sedentary behaviour or physical activity, or their combination were reported; and articles had to be written in English, Spanish, French, Portuguese, German, Italian or Chinese.

Findings and conclusions

Data extraction, results, studies' quality, and risk of bias were evaluated using the Consensus-based Standards for the selection of health Measurement Instruments (COSMIN) guidelines. Fifty-five articles were included in this review, describing 60 questionnaires.

[CEECIND/01089/2017]; BR/UI/BD/150675/2020] and by The National Physical Activity Promotion Program of the Directorate-General of Health (Portugal). The funding agencies played no role in the study design; the collection, analysis, and interpretation of data; the writing of the report; and in the decision to submit the article for publication. The views expressed herein do not necessarily represent the views of the Directorate-General of Health.

Competing interests: The authors have declared that no competing interests exist.

None of the questionnaires showed adequate criterion validity and adequate reliability, simultaneously; 68.3% showed adequate content validity. The risk of bias for criterion validity and reliability were very low in 72.2% and 23.6% of the studies, respectively. Existing questionnaires have insufficient measurement properties and frequent methodologic limitations, and none was developed considering the 24h movement behaviour paradigm. The lack of valid and reliable questionnaires assessing 24h movement behaviours in an integrated way, precludes accurate monitoring and surveillance systems of 24h movement behaviours.

1. Introduction

In light of the recent 24h movement behaviour paradigm [1], sleep, sedentary behaviour (SB) and physical activity (PA) are constituent parts of a 24h period that interact and influence health. This new paradigm has led some countries, as well as the World Health Organization (WHO) to develop 24h movement guidelines [2–4]. With its development and launching in other countries there is a tangible need to accurately assess movement behaviours in an integrated way; and monitoring and surveillance systems will need to be adapted to assess compliance with such guidelines. The accurate assessment of movement behaviours is also essential for research, policy, and practice. Despite the advantages of objective methods to assess movement behaviours, such as accelerometry (e.g., do not depend on participant recall) in large epidemiological studies and clinical settings, self- or proxy-reported questionnaires are often preferred, given their practicality, simplicity, affordability, and low burden for participants (in terms of time consuming and acceptability) [5–7]. Moreover, these are capable of gathering valuable contextual information (e.g., domains, settings, types) of the behaviours, that objective measures are unable to [8]. Nevertheless, assessing 24h movement behaviours is challenging and complex, given that movement behaviours questionnaires are often prone to measurement errors and reporting bias due to misreporting, whether due to social desirability bias or cognitive issues related to recall or comprehension [9].

The usefulness of a self-reported measure is dictated by its qualitative attributes (i.e., content validity) and psychometric properties, such as test–retest reliability and criterion validity. As such, questionnaires must be adequately developed and described, presenting adequate content and measurement properties, because if the development method and the measurement properties are weak or not extensively known, the risk of misclassification, biased and unreliable results is high [10].

The self-reported assessment of movement behaviours has generally been done by assessing each behaviour *per se* and consequently, evidence of the content analysis and measurement properties of the instruments used to assess these behaviours has also been done in isolation. Recently, two systematic reviews [11, 12] on measurement properties of PA questionnaires reported several limitations, particularly related to statistical methods and accelerometry interpretation; and that the methodological quality of the studies could be improved by increasing sample size, enhancing statistical procedures and reporting methods, and choosing better comparison measures for validity studies. Regarding SB, two other systematic reviews [13, 14] reported poor levels of agreement and accuracy with under and overestimation of total time spent in SB. Altogether, these reviews indicate that precise self-report instruments to measure PA and SB are still scarce [15]. Concerning sleep questionnaires, these seem to be primarily used as a diagnostic tool and to be relatively accurate [16]. Despite the reduced accuracy

when compared with diaries and objective instruments, questionnaire-based data is considered relevant due to the importance of each person's self-perception about their sleep [16]. However, it is unclear whether there are questionnaires assessing sleep considering it as part of a 24h period (i.e., as a movement behaviour).

The fact that movement behaviours have traditionally been subjectively assessed individually (each behaviour *per se*) and ignoring the intrinsic and empirical interactions between them [17, 18], may partly be because there is no single questionnaire that assesses 24h movement behaviours in an integrated way. Selecting the best questionnaire for each movement behaviour (or their combination) is difficult, given the high variability in their content and the inadequate measurement properties. This has been documented in previous reviews [11, 12, 14, 16, 19, 20]. However, none of these reviews assessed the questionnaires that measure the combination of these behaviours at the same time. Therefore, reviewing the questionnaires measuring all the movement behaviours, individually or in combination, in adults and older adults, is necessary. In this context, we aimed to systematically review the literature on content and measurement properties of self- and proxy-reported questionnaires measuring the movement behaviours or its combination, in adults and older adults.

2. Materials and methods

2.1 Information sources and search strategy

A systematic search through the electronic databases PubMed, CINAHL, PsycINFO and SPORTDiscus was conducted in April 2021, from inception until April 2021. Additional studies were identified by manually searching references of the retrieved papers.

The electronic databases were searched for variations of the terms 'PA', 'SB', 'sleep', 'movement behaviours', 'questionnaire' and 'measurement properties'. A supporting file shows this in more detail [see S1 File]. The search terms used for 'measurement properties' were the ones proposed by COSMIN guidelines [21]. The search terms were adapted for each specific electronic database to ensure the quality of the systematic searching (e.g., in PubMed's case, MESH terms were used when applicable).

2.2 Eligibility criteria

Consensus-based Standards for the selection of health Measurement INstruments (COSMIN) guidelines for systematic reviews of patient-reported outcome measures [21], were adapted to the purpose of this review and followed. The COSMIN guidelines are in concordance with the Cochrane Handbook for systematic reviews of interventions [22] and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [23].

To identify and characterize valid and reliable self-reported or proxy-reported questionnaires assessing sleep, sedentary behaviour and physical activity, or their combination, the following inclusion criteria were defined: 1) participants were adults (≥ 18 years) or older adults (≥ 65 years), living in the community; 2) minimum sample size of 50 participants for validity studies [24]; 3) articles reporting at least, both validity and test-retest reliability results [25] of questionnaire that were developed specifically to measure the amount of sleep, SB or PA, or its combination; 4) articles written in English, Spanish, French, Portuguese, German, Italian or Chinese.

The exclusion criteria were the following: 1) articles that used doubly labelled water as gold standard for validity purposes, given that doubly labelled water assesses total energy expenditure, not only PA energy expenditure and, as such, it has been considered an unreliable criterion measure for PA levels [11, 25]; 2) reporting measurement properties of instruments that aimed solely to predict or detect a given health condition, designed for special populations

(e.g., chronic, auto-immune and infectious diseases, sleep disorders, athletes, pregnant women) or focused only on lifetime PA; 3) reporting measurement properties of questionnaires that were not designed to validate an original questionnaire (e.g. reported linguistic validation); 4) articles reporting measurement properties of logs, diaries or interviews of movement behaviours; 5) grey literature (e.g. policy reports; government documents; working papers; conference proceedings; thesis and books or book chapters), reviews, meta-analyses, cost-effectiveness studies and commentaries.

2.3 Study selection process

Three authors (BR, JE and EVC) independently screened articles by title, abstract and full text. Results were cross-checked and disagreements were resolved by discussion with a fourth author (RS), until consensus was reached. Reference lists of identified articles were also reviewed to ensure that no relevant articles were overlooked. These processes were conducted using the CADIMA software [26].

2.4 Data collection process and data items

A standardized data extraction form was created to record relevant information from the included articles about the questionnaires' content, validity, reliability, measurement error and responsiveness. A supporting file shows this in more detail [see [S2 File](#)].

Given the characteristics of this review, the data extraction on content and measurement properties was based on the COSMIN guidelines [21], the Taxonomy of Self-reported SB Tools (TASST) framework [13] and the Quality Assessment of PA Questionnaire Checklist (QAPAQ) [25]. For measurement properties, the Edinburgh Framework for validity and reliability in PA and SB measurement was also considered [27]. When needed, adaptations have been made to integrate sleep as a movement behaviour. The measurement properties' definitions used in this study are presented in [Table 1](#).

Table 1. Measurement properties definitions.

1. Measurement Property	Definition
1.1. Validity	The degree to which an instrument truly measures the construct(s) that wants to measure, free from all possible sources of error or bias.
1.1.1.1. Convergent validity	The extent of the agreement with another (non-criterion) measure that should assess the same behaviour parameter based on face and content validity.
1.1.1.2. Criterion validity	The extent of the correlation between a measure and another already considered as being a criterion or gold standard.
1.2. Reliability	The extent to which an instrument gives consistent, stable, and repeatable measurement. In other words, it is free from measurement error.
1.2.1. Test-Retest	The extent to which test scores are consistent from one test administration to the next, keeping the same conditions (e.g., researcher, timing, preparation, etc.)
1.2.2. Measurement Error	How close the scores on repeated administrations are, expressed in the unit of the questionnaire (i.e., Limits of Agreement (LOA); Standard Error of Measurement (SEM); Smallest Detectable Change (SDC)).
1.2.3. Reliability Coefficients	The proportion of the total variance in the measurements, which is due to consistent differences between subjects (i.e., Intraclass Correlation Coefficient (ICC) and Confidence Intervals (CI) and Cohen's Kappa coefficient (ordinal measures)).
1.3. Responsiveness	The ability of an instrument to detect change over time in the construct to be measured. Refers to the validity of a change score.

Based on: COSMIN guidelines [21] and Edinburgh Framework [27].

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2.5 Study risk of bias assessment

The Risk of Bias checklist developed by COSMIN is exclusively for assessing the methodological quality of single studies included in systematic reviews of questionnaires [21]. Given the characteristics of this review, this checklist was adapted. The checklist herein presented has a 4-point scale (i.e., 'very low risk', 'low risk', 'medium risk' or 'high risk'), and contains items on criterion validity, reliability, measurement error and responsiveness. For each measurement property, different design requirements and statistical methods were rated based on the COSMIN standards. Each measurement property was evaluated separately. The overall rating was determined based on "the worst score counts" method as proposed by COSMIN. The criteria for each item can be found in COSMIN guidelines [21]. For reliability, as previously done [19], we defined an 'adequate' time interval between test and retest as follows: > 1 day and ≤ 3 months for questionnaires recalling a usual week/month; > 1 day and ≤ 2 weeks for questionnaires recalling the previous week; > 1 day and ≤ 1 week for questionnaires recalling the previous day; > 1 day and ≤ 1 year for questionnaires recalling the previous year.

The data was collected independently by 3 authors (BR, JE and EVC) and disagreements were resolved by discussion with a fourth author (RS).

2.6 Effect measures

2.6.1 Quality of measurement properties. To evaluate the studies' quality of measurement properties we followed the COSMIN guidelines; as such, all measurement properties were rated against quality criteria for good measurement properties [28]. Each result was rated as 'adequate' (+), 'inadequate' (-), or 'doubtful' (?) when design or method was not well reported (e.g., lack of information regarding sample characteristics, lack of information regarding criterion validity).

A study was considered to have 'adequate' criterion validity when results for correlations between the questionnaire and the criterion instrument were ≥ 0.70 . The accelerometer was considered a criterion measure because, despite that there is no gold standard to measure all movement behaviours, the accelerometer is the only instrument able to do it with proved accuracy and is widely used as criterion comparison measure in validation studies of movement behaviours' questionnaires [5].

For convergent validity, statistically significant correlations ($p < 0.05$) between the movement behaviour and assessments related to the behaviour in question (e.g., between PA and VO_{2max}) of ≥ 0.5 and correlations between the movement behaviour measured by similar self-reported instruments of ≥ 0.7 were considered 'adequate'.

For reliability, Intraclass Correlation Coefficient (ICC) or weighted Kappa ≥ 0.70 were considered 'adequate'; the use of Pearson or Spearman correlation coefficients was considered 'inadequate', because it does not have into account systematic errors [29]. However, Pearson and Spearman correlations > 0.80 were rated positively, similarly to what has been previously done [11].

Measurement error was considered 'adequate' when the smallest detectable changes or limits of agreement (LoA) were inferior to minimal important change, and 'doubtful' when minimal important change was not defined.

Responsiveness was considered 'adequate' when the result was in accordance with the hypothesis or Area Under the Curve (AUC) ≥ 0.70 , and 'doubtful' when no hypothesis was defined.

For the overall rating of the quality of the studies, if 75% of the results *per* study were 'adequate', the overall rating was considered 'adequate'.

2.6.2 Content validity. Given the characteristics of our search strategy, we did not perform a comprehensive analysis of content validity, but rather applied a subjective reviewers'

rating to assess the content validity of all included questionnaires, as suggested by COSMIN guidelines [21]. In this analysis, several aspects were evaluated as ‘adequate’ (+) or ‘inadequate’ (-), such as: 1) items relevance for the construct, population, and context of use (i.e., the item had to be directed related to the construct or behaviour evaluated); 2) response options and recall period appropriateness for construct, population and context of use (i.e., closed response options were considered inappropriate because they do not capture the movement continuum; the recall period and context had to be clearly stated); 3) comprehensiveness of the construct, population and context of use (i.e., key aspects, such as duration or intensity related to the construct or behaviour had to be clearly stated); and 4) language appropriateness of the response options and items (i.e., clear and simple language).

To evaluate content validity, if the questionnaire was not integrated in the article, we either contacted the authors requesting for the questionnaire or searched online to find it. If access to the questionnaire was not possible, we rated it with ‘cannot be determined’.

2.7 Synthesis methods

We conducted a narrative synthesis of the results and organized it in the respective tables (as presented in the results section below).

3. Results

3.1 Search results

The search yield 16,182 articles after removing duplicates. Twelve articles were added after searches in other reviews. Based on titles and abstracts, 108 full texts were selected, and 55 were included, describing 60 questionnaires. The reasons for exclusion of full texts are described in Fig 1.

3.2 Results of synthesis

3.2.1 Content description. Twenty-five questionnaires measured PA (17 in adults [30–42], four in older adults [43–46] and four in adults and older adults [47–50]), 12 measured SB (eight in adults [51–58], three in older adults [59, 60] and one in adults and older adults [61]), one measured sleep (in adults and older adults [62]), 12 measured the combination of PA and SB (five in adults [63–67], three in older adults [68–70] and four in adults and older adults [71–74]), one measured the combination of SB and sleep (in adults [75]), and nine measured the combination of PA, SB and sleep (six in adults [67, 76–80], three in adults and older adults [81–83]). There were no proxy-reported questionnaires.

Regarding PA questionnaires [30–50], 68% assessed multi-domain PAs, with leisure-time PA being the most frequent domain (measured in 19 out of 25 PA questionnaires included). The most prevalent response method was the continuous method (68%), focusing on different metrics (e.g., hours/day). The most frequent measurement unit was METs/hour or minute per week or minutes per day (44%). Most of the questionnaires (72%) assessed multiple scores. Recall periods varied from past year (24%), past week (52%), usual week (24%) to currently (12%). None of the questionnaires specified the assessment period (whether a participant is asked regarding a particular type of day, e.g., only weekend days). The number of items included in the PA questionnaires ranged from one to 74.

In the SB questionnaires [51–61], the most prevalent domains were total SB/sitting time (50%) and multi-domain (41.7%). The continuous response method was the most prevalent (66.7%), in hours per day (41.7%) and minutes per day (41.7%). The measurement units depended on the objective of assessment, and the most used score was total SB (91.7%). The

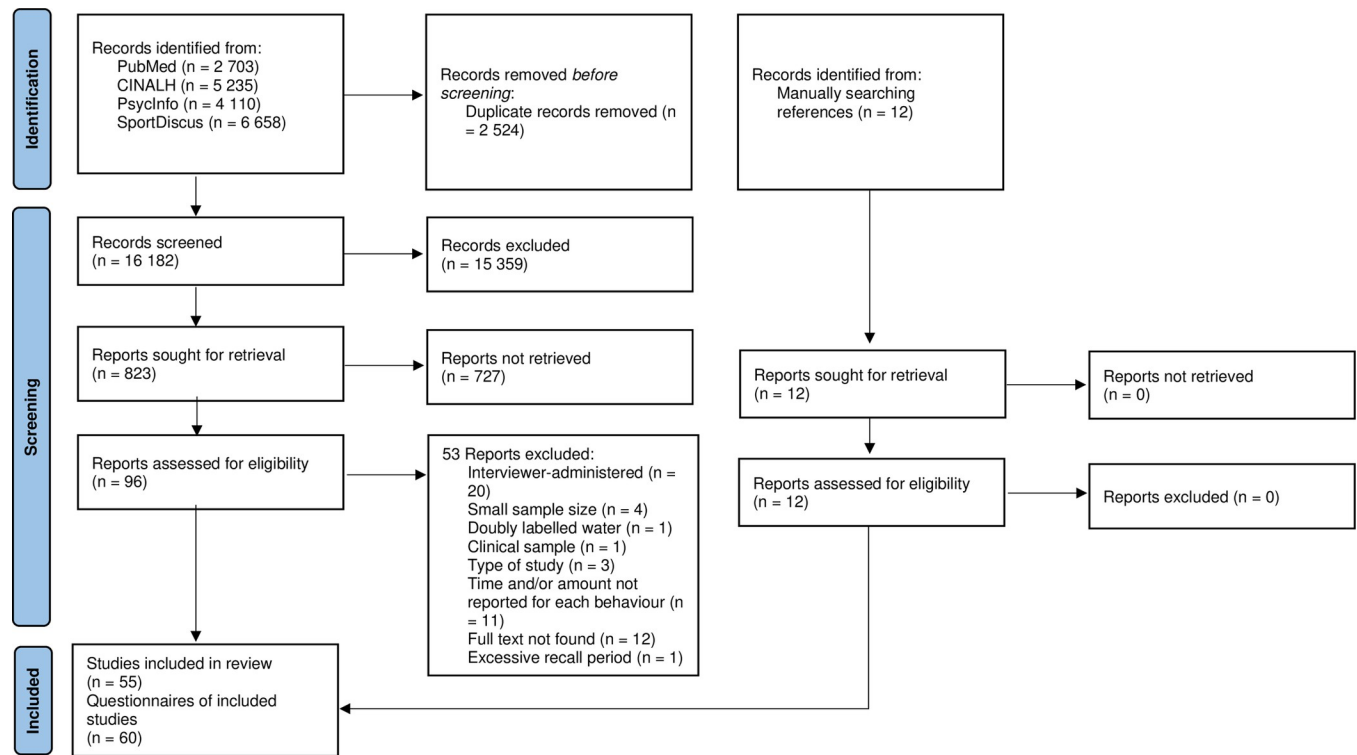


Fig 1. Study selection process flowchart.

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most frequent recall periods were past week (33.3%) and usual day (33.3%). Assessment period was specified in 66.7% of the SB questionnaires. The number of items included in the questionnaires ranged from 1 to 20.

There was only one questionnaire assessing sleep duration (Behavioral Risk Factor Surveillance System (BRFSS) Sleep questionnaire) [62]. The response method was continuous, and the measurement unit was hours/day. The recall period was a usual day.

The questionnaires combining PA and SB [63–74], mostly assessed the behaviours through multi-domain (83.3%) with the occupational domain being the most prevalent (11 out of 12 questionnaires). The occupational domain was also used in single domain questionnaires [71, 72]. The most prevalent response method was the continuous method (75%) focusing on different metrics (e.g., hours/week). The most prevalent measurement unit was time (75%) (e.g., hours/week) and several scores were evaluated in all questionnaires, rather than just one score. The most frequent recall periods were usual day/week (66.7%). Assessment period was not specified in 66.7% of the questionnaires. The number of items included in the questionnaires ranged from 3 to 75.

One questionnaire assessed both SB and sleep [75]. This questionnaire had 41 items assessing multi-domain behaviours, the response method was continuous, the measurement unit was hours/day with multi-scores evaluated and the assessment period was specified.

All, except two [79, 81] of the questionnaires measuring a combination of PA, SB, and sleep [67, 76–83] assessed these behaviours through multiple domains. The most prevalent response method was the continuous method (77.8%), focusing on different metrics (e.g., hours/week). The most prevalent measurement units for SB and PA were energy and intensity variables (77.8%) (e.g., METs, kcals) and several scores were evaluated in all questionnaires. For sleep

items, the measurement unit was always hours/day. The recall periods focused on the past (55.6%) and in the usual activity (44.4%). Assessment period was not specified in 77.8% of the questionnaires. The number of items included in the questionnaires ranged from 5 to 448. Among these questionnaires, none was designed in terms of content and final scores, to assess all movement behaviours considering the 24h movement behaviour paradigm. The characteristics of the included questionnaires included are presented in [Table 2](#).

3.2.2 Content validity. [Table 3](#) presents the summary of the content validity results and its details are provided in a supporting file [see [S1 Table](#)]. Most of the questionnaires (68.3%) showed 'adequate' content validity.

Regarding PA questionnaires, only three were considered 'inadequate' (two in adults [[33](#), [34](#)] and one in adults and older adults [[43](#)]). Three questionnaires (in adults) [[33](#), [35](#), [36](#)] were not available, therefore, their content validity could not be determined.

For SB, three questionnaires (two in adults [[55](#), [56](#)] and one in adults and older adults [[61](#)]) were considered to have inadequate content validity. One questionnaire [[57](#)] was not assessed as its content was not available.

The sleep questionnaire was considered to have 'adequate' content validity. For PA and SB, three questionnaires were considered to have 'inadequate' content validity (one in adults [[63](#)], one in older adults [[68](#)] and one in both [[73](#)]).

The SB and sleep questionnaire [[75](#)] was considered with adequate content validity.

For PA, SB and sleep questionnaires 4 questionnaires were considered 'inadequate' (two in adults [[76](#), [80](#)] and two in adults and older adults [[82](#)]). One questionnaire [[81](#)] (in adults and older adults) was not available, therefore, their content validity could not be determined.

The main reason for the content validity inadequacy was the response options not being appropriate (i.e., closed response, rating scales).

3.2.3 Validity. [Table 3](#) presents the summary of the results for validity, and its details are provided in a supporting file [see [S2 Table](#)]. Only the Athens Physical Activity Questionnaire (APAQ) [[77](#)] had 'adequate' overall quality for criterion validity and the International Physical Activity Questionnaire (IPAQ) [[65](#)] had 'adequate' overall quality for convergent validity. Overall, 36.7% of the studies did not specify the sample characteristics. The most frequently calculated coefficients were Pearson and Spearman correlations, Kappa's coefficients, percentages of agreement and intraclass correlation coefficients. Bland and Altman statistics examined measurements of precision in 30% of the questionnaires.

In the PA questionnaires, none of the questionnaires showed overall 'adequate' criterion or convergent validity. Criterion validity was assessed with accelerometry in 76% of the questionnaires; however, the accelerometer protocols used (e.g., epoch length, valid day definition) varied substantially between studies. The best results with accelerometry were regarded Self-Report Physical Activity Questionnaire (SPAQ) light, moderate and household PA scores [[48](#)], and Transport and Physical Activity Questionnaire (TPAQ) vigorous PA score [[49](#)]. Some questionnaires [[34](#), [35](#), [42–44](#)] only assessed convergent validity and these were performed against other subjective measures or variables related to PA behaviour (e.g., VO_{2max} , body fat). The CARDIA Physical Activity History (CARDIA) [[33](#)], Minnesota Heart Health Program Questionnaire (MHHP Q) [[33](#)], 13-Item Physical Activity Questionnaire (13I-PAQ) [[42](#)] and Incidental and Planned Exercise Questionnaire (IPEQ) [[44](#)] questionnaires were the ones showing the best convergent validity in some scores.

Regarding SB questionnaires, none showed overall 'adequate' criterion or convergent validity. The accelerometer was the criterion measure in 91.7% of the questionnaires. The Australian Longitudinal Study on Women's Health—Sedentary Behaviour Questions (ALSWH-SB Q) [[52](#)] showed the best convergent validity scores; nevertheless, these only took into account computer use ($r = 0.74$) and occupational SB (ICC = 0.77).

Table 2. Characteristics of the included movement behaviour questionnaires.

Questionnaire	Age Group, Country	Domains	Response Method	Units of Measurement	Scores	Recall Period/Assessment period	# Items	Parameters
Physical Activity								
Nord-Trøndelag Health Study PA Questionnaire (HUNT 1) [29]	Adults, Norway	Leisure	Rating Scale: F: 1–5 (Never–Almost every day); I: 1–3 (without losing breath–near exhaustion); D: 1–4 (<15 min—>60 min)	Weekly physical activity Index (product of F, I and D scales)	F; I; Index	Currently	3	F; D; I
Past Year Total Physical Activity Questionnaire (PYTPAQ) [30]	Adults, Canada	Occupational; Household; Leisure; Transportation	Continuous: hour/day; Days/week	MET's hour/week	Total physical activity; Occupational physical activity; Leisure physical activity	Past year	Open table (6 parameters)	F; D; I; M
Physical Activity Assessment Tool (PAAT) [31]	Adults, USA	Total physical activity	Continuous: days/week; min/day	min/week	MPA; VPA; Total physical activity; Active or Inactive	Past week	19	F; D; I
Minnesota Leisure Time Physical Activity Questionnaire (Minnesota LTPAQ) [32]	Adults, USA	Leisure	Continuous: Times/month; hour/Day	MET's min/day	Total Leisure time physical activity; Light; MPA; VPA; household chores	Past year	74	D; I
Single Item Physical Activity Measure (SI PA M) [33]	Adults, UK	Total physical activity	Continuous: n° of days	Active days (>30mins)	Number of active days/week	Past week; past month	2 separate questions	F; D
Godin Questionnaire (Godin Q) [32]	Adults, USA	Leisure	Continuous: Times/week	Times/week	Total physical activity; VPA; MPA; LPA; Leisure score	Usual week	4	F; I
CARDIA Physical Activity History (CARDIA) [32]	Adults, USA	Total physical activity	Categorical—yes/no; Continuous: n° months; n° months certain hour/week	hour/month	MPA; VPA; Total physical activity	Past year	3	F; D; I
College Alumnus Questionnaire (College Alumnus Q) [32]	Adults, USA	Leisure; Sport; Transport	Continuous: min/day	MET's min/day	EE based on stairs, walking and sports (total index)	Currently; past week; past year	7	F; D; I
Minnesota Heart Health Program Questionnaire (MHHP Q) [32]	Adults, USA	Occupational	?	MET's min/day	Work index; leisure index	Currently	6	D; I
Modified Historical Leisure Activity Questionnaire (MHLAQ) [34]	Adults, USA	Leisure; Household and childcare activities; Occupational	Continuous: N° months/year; hour/week	MET's hour/week	Total physical activity; MPA; VPA; Leisure physical activity; Household physical activity	Past year	?	F; D; I
Modified version Active Australia Survey 1 (MV–AAS1) [35]	Adults, Australia	Leisure	Continuous: hours or minutes; Frequency	MET's min/week for categories; min/week for continuous scores; frequency/week	Total physical activity; VPA; MPA; Walking; MVPA; physical activity categories	Past week	?	F; D; I
Modified version Active Australia Survey (MV–AAS2) [36]	Adults, Australia	Leisure	Continuous: hours or minutes; Frequency	min/week and days/week	VPA; MPA; Walking; MVPA; Meet physical activity guidelines	Past week	8	F; D; I
Adapted from Active Australia Survey (Adapt AAS) [37]	Adults, Australia	Leisure; Occupational, Transport; Household	Continuous: hours or minutes; Frequency	min/day	Total physical activity; VPA; MPA; Walking; Meet guidelines	Past week	6	F; D; I
International Physical Activity Questionnaire–Walking Section (IPAQ–WS) [38]	Adults (Australia, Brazil, Finland, Japan, Portugal, Sweden, the Netherlands, UK and USA)	Walking	Continuous: hours or minutes; Frequency	min/week	Walking; Walking + MPA	Past week; Usual week	2	F; D

(Continued)

Table 2. (Continued)

Questionnaire	Age Group, Country	Domains	Response Method	Units of Measurement	Scores	Recall Period/Assessment period	# Items	Parameters
Short Questionnaire to Assess Health-enhancing physical activity (SQUASH) [39]	Adults, Netherlands	Transport; Leisure; Household; Occupational	Continuous: Days per week; hours and mins per activity/Day; Rating scale for intensity: Slow; Mod; fast or light; MPA; Intense	min/day	Total minutes; Activity score (minutes $\times$ intensity)	Usual week	11	F; D; I; M
European Prospective Investigation into Cancer and Nutrition Physical Activity Questionnaire (EPIC PAQ) [40]	Adults, Australia	Occupational; Household; Leisure	Categorical for work: Sedentary occupational—Heavy manual work; Continuous: hour/week	METs hour/week	Total non-occupational physical activity; Recreational physical activity; Household physical activity; VPA (self-rated); VPA (MET assigned); LPA to MPA	Past year, during a usual week in summer and winter	17	F; D; I; M
13-Item Physical Activity Questionnaire (13I-PAQ) [41]	Adults, Czech Republic	Leisure; Occupational; Household	Continuous: hour/day	hour/Week	Total physical activity; Sport physical activity; non-sport LTPA; Occup physical activity; Household	Usual week	13	F; D; M
Questionnaire d'Activité Physique pour les Personnes Agées (QAPPA) [42]	Older adults, France	Occupational; Household; Leisure; Transportation	Multiple Choice (activities); Continuous: Days/week	METs min/week	Total physical activity; VPA; MPA	Past week	6	F; D; I; M
Incidental and Planned Exercise Questionnaire (IPEQ) [43]	Older adults, Australia	Leisure time, household	Continuous: Times/week; Rating Scale: various	hour/Week	Incidental and planned physical activity	Past week version and Past 3 months version	10 each version	F; D; M
Physical Activity Questionnaire for Elderly Japanese (PAQ-EJ) [44]	Older adults, Japan	Transportation; Exercise/sport; Household; Occupational	Rating Scale: 1–4 (various)	METs hour/week	Total PAQ-EJ; Subtotal Lower intensity categories; Subtotal higher intensity categories	Usual week	14	F; D; M
The Longitudinal Ageing Study Amsterdam Physical Activity Questionnaire (LAPAQ) [45]	Older adults, Netherlands	Walking; transport; household; Leisure; sport	Continuous: Times week; hours and min/past 2 week	METs	METs ($> = 6$ METs; 3–5.99 METs; 2–2.99); Total physical activity $> = 2$	Past 2 weeks	18	F; D; M
Nordic Physical Activity Questionnaire (NPAQ-short) [46]	Adults and Older adults, Denmark	Leisure; Transport	Rating scale: 1–5 (< 30 mins $\rightarrow > 5$ hours (MVPA) or > 150 min (Vig)); Continuous: hour/week or min/week	min/week	MVPA; VPA; Compliance with WHO guidelines	Past week	4	D; I
Self-report physical activity questionnaire (SPAQ) [47]	Adults and Older adults, Thailand	Household; Occupational; Leisure; Transport	Continuous: Times/week; Rating scale: 1–6 (0–1 hours $\rightarrow > 9$ hour/week)	MET hour/week	Total physical activity; LPA; MPA; household physical activity; occupational physical activity; leisure time recreation; leisure time exercise; transportation	Past week	55	F; D; M
Transport and Physical Activity Questionnaire (TPAQ) [48]	Adults and Older adults, UK	Leisure; Transport	Continuous: number of trips, the total time spent (hours and minutes), the total distance (miles) travelled	mins/week	Walking for transport; Walking for recreation; Cycling for transport; Cycling for recreation; Moderate Leisure time physical activity; Vigorous Leisure time physical activity; Total physical activity	Past week	16	F; D; M

(Continued)

Table 2. (Continued)

Questionnaire	Age Group, Country	Domains	Response Method	Units of Measurement	Scores	Recall Period/Assessment period	# Items	Parameters
General Practice Physical Activity Questionnaire (GPPAQ) [49]	Adults and Older adults, UK	Occupational; Leisure	Occup: Categorical about physical activity amount and type. Leisure physical activity: Rating scale 1–4 (None–≥3 hours). Walking pace: Rating scale 1–4 (Slow–Fast)	hour/week	Activity category (active, moderately active, moderately inactive or inactive)	Past week	7	D
Sedentary Behaviour								
International Physical Activity Questionnaire—Sedentary Behaviour (IPAQ-SB) [50]	Adults, UK, USA, Netherlands	Total sedentary behaviour	Continuous: hours and minutes	hour/Day	Total Sitting time	Past week, on weekdays and weekend days	2	D
Australian Longitudinal Study on Women's Health—Sedentary Behaviour Questions (ALSWH—SB Q) [51]	Adults, Australia	Transport; Occupational; Watching TV; Using computer at home; Leisure	Continuous: hours and minutes	hours and min/day	Transport; Occupational; Watching TV; Using computer at home; Leisure time	Currently, on weekdays and weekend days	5	D
Self-reported sitting and breaks from sitting in the workplace (SBSW) [52]	Adults, Australia	Occupational	Continuous: hours and/or minutes; Frequency breaks per hour	min/day for sitting; Frequency/hour work breaks	Sitting; breaks from sitting	Past week, on workdays	2	F; D
Workplace Sitting Breaks Questionnaire (SITBRQ) [53]	Adults, Australia	Occupational	Rating scale: n° of breaks; hours in breaks per day	Breaks/hour; min/day	Frequency of breaks; Total duration of breaks	Usual workday	2	F; D
Sedentary Behaviour Questionnaire (SBQ) [54]	Adults, USA	TV; Computer games; sitting listen to music; office/paperwork; Reading; Play musical instrument; Arts and crafts; sitting driving a car.	Rating Scale: 0–6; (None—> 6 hours)	hour/week; hour/day	TV; Computer games; sitting listen to music; sitting talking on telephone; office/paperwork; Reading; Play musical instrument; Arts and crafts; sitting driving a car. Total hour/week; total hour/weekday; total hour/weekend	Usual weekday; Usual weekend day	18	D; M
SED-GIH [55]	Adults, Sweden	Total sitting time	Rating scale: 1–7 (Never—Virtually all day)	Categorical: hour/day	Total sitting time	Usual day	1	Duration
Workforce Sitting Questionnaire (WSQ) [56]	Adults, Australia	Transport; Occupational, TV; Computer; Leisure	Continuous: min/day	min/Day	At work, workday; Total, all domains, workday; Total, all domains, non-workday; Average total, work and non-workdays	Past week, on workdays, and non-workdays	?	D; M
Japanese-Language Self-reported Measures for Assessing Adults Domain-Specific Sedentary Time (ISRMSB) [57]	Adults, Japan	Transport, Occupational; TV; Computer use; Other leisure time	Continuous: min/day	min/day	Total Sitting time at workday, non-workday, and whole week	Past week, on workdays and non-workdays	6	D; M
Longitudinal Aging Study Amsterdam questionnaire (LASA) [58]	Older adults, Netherlands	Leisure; Occupational; Transport; Household; TV	Continuous: hours and min/day	hour/day	Total sitting time	Usual week and weekend day	20	D; M
SB question of the Yale Physical Activity Survey (YPAS—SB) [59]	Older adults, USA	Total sedentary behaviour	Continuous: hour/day	hour/day	Total sitting time	Usual day	1	D

(Continued)

Table 2. (Continued)

Questionnaire	Age Group, Country	Domains	Response Method	Units of Measurement	Scores	Recall Period/Assessment period	# Items	Parameters
Community Health Activities Model Program for Seniors SB questions (CHAMPS-SB) [59]	Older adults, USA	Total sedentary behaviour	Continuous: hour/week	hour/week	Total sitting time	Usual week	9	D; F
Cancer Prevention Study-3 Sedentary Time Survey (CPS-3 sitting time) [60]	Adults and older adults, USA	Total sitting time	Rating scale 1–8 (0 = +11 hours)	hour/Day	Total sitting time	Past year, on weekdays and weekend days	4	D; M
Sleep								
BRFSS sleep questions (BRFSS Sleep) [61]	Adults and older adults, USA	Duration	Continuous: hour/day	hour/Day	Total sleep time	Usual day	1	D
Physical Activity + Sedentary Behaviour								
Kaiser Physical Activity Survey (KPAS) [62]	Adults, USA	Leisure; Occupational; Household; Transport, TV	Rating scale 1–5 (caringiving section: 1–4 (never-always); Other sections: 1 to 5 (none) >20 hour/week), various options)	Activity score; Frequency and duration for the three most frequent sports/exercise	Caregiving; Housework; Housework/caregiving; Sports/exercise; Active living habits; Occupational; 3-point or 4-point summary	Past year	75	F; D
Sedentary, Transportation and Activity Questionnaire (STAQ) [63]	Adults, France	Occupational, Transport, Leisure	Continuous: hour/week or day/week. Categorical (various options)	hour/week or day/week	Total, work, transport, leisure; leisure sedentary behaviour: total, screen time, reading, writing, listening to music, sewing	Past month on workdays and non-workdays	56	D; F; M
International Physical Activity Questionnaire (IPAQ) [64]	Adults, Australia, Brazil, Canada, Finland, Guatemala, Netherlands, Japan, Portugal, South Africa, Sweden, United States, San Diego, United States, South Carolina, United Kingdom	Long form: Occupational, Transport, Household, Garden, Leisure, Sitting time. Short Form: Total physical activity, Sitting time	Continuous: Frequency, hours and minutes	MET-min/week for physical activity; min/week for Sitting time; Guideline's compliance (yes or no)	Total physical activity; Total sitting time; Guideline compliance	Past 7 days or usual week on weekdays and weekend days	Short Form 7; Long Form 27	F; D; I; M
Australian Women's Activity Survey (AWAS) [65]	Adults, Australia	Planned activities, employment, childcare, domestic responsibilities, and transportation	Dichotomic: yes/no; Continuous: hours, days, min)	min/week	Sitting; LPA; MPA; VPA; Total activity	Usual week on the past month	72	F; D; I
Workers' sitting- and walking-time questionnaire Time Method (WSWQ- t-method) [66]	Adults, Japan	Occupational; Leisure	Continuous: hours and mins	hours and mins	Sitting and walking/standing during working time and non-working time; sitting and walking/standing during non-workday	Usual day on the past month	6	D
The Physical Activity Scale for the Elderly (PASE) [67]	Older adults, UK	Occupational; Household; Leisure; Sports	Rating scale: 1–4 never—often; less than 1h - more than 4h	METs Hour/day	PASE activity score	Past week	23	F; D; I; M
Community Health Activities Model Program for Seniors physical activity self-report questionnaire + transport items (CHAMPS+transport) [68]	Older adults, USA	Leisure; Occupational; Household; Transportation; Watching TV	Continuous	times/week; METs hour/week	Sedentary time; low-LPA, high-LPA; MVPA; Total physical activity	Usual week on the past month	52	F; D; I; M

(Continued)

Table 2. (Continued)

Questionnaire	Age Group, Country	Domains	Response Method	Units of Measurement	Scores	Recall Period/Assessment period	# Items	Parameters
Community Healthy Activities Model Program for Seniors (CHAMPS) [69]	Older adults, USA	Leisure; occupational; household; transportation, watching TV	Continuous: Times/week; hour/week	times/week; METs hour/week	Caloric expenditure per week in at least moderate intensity physical activities; frequency per week in at least moderate intensity physical activities; Caloric expenditure per week in all listed physical activities; Frequency per week in all listed physical activities	Usual week on the past month	41	F; D; I; M
Modified Version of the MONICA Optional Study on Physical Activity Questionnaire (Modified MOSPA-Q) [70]	Adults and older adults, Australia	Occupational	Continuous: hours and mins	min/workday	Lifting/Carrying; Standing; Sitting; Walking	Usual workday on the past week	4	D; M
Occupational Sitting and Physical Activity Questionnaire (OSPAQ) [70, 71]	Adults and older adults, Australia	Occupational	Continuous: hours and mins; Percentage	min/workday	Heavy labour; Standing; Sitting; Walking	Usual workday on the last 7 days	6	D; M
Rapid Assessment Disuse Index (RADII) [72]	Adults and older adults, USA	Total physical activity and sitting time	Rating scale 1–5 (number of hour/day)	Index based on hour/day or number of flights	Moving; number of flights of stairs; Sitting time; RADII scores	Usual day on the past week/month/year	3	D
Global Physical Activity Questionnaire (GPAQ) [73]	Adults and Older adults, Japan	Occupational; transportation; Leisure	Dichotomic: yes/no; Continuous: hours, days, mins	min/week; hour/week	Work Domain: Sedentary, Vigorous intensity, Moderate intensity, Total; Transport: walking and cycling, Total; Leisure Domain: Sedentary, Vigorous intensity, Moderate intensity, Total	Usual day, typical week	19	F; D; I
Sedentary Behaviour + Sleep								
SITT-Q [74]	Adults, Australia	Sleep; Napping; Transportation; Occupational; Household; Leisure	Continuous: hour/day	hour/day	Meals; Transportation; Occupational; Child and elder care; TV; computer use; Leisure; Total sitting time	Past year in usual day, on weekdays and weekend day	41	D
Physical Activity + Sedentary Behaviour + Sleep								
Physical Activity Questionnaire (PAQ) [75]	Adults, Sweden	Occupational; Leisure; Household; Sitting/TV/reading; Walking/bicycling; Sleep	Rating scale 1–5 (Various); Sleep (continuous: hour/day)	METs-hour/day	Crude Total physical activity; Total activity score; Work/occupation; Home/household work; Active leisure-time (walking/bicycling + exercise); Inactive leisure-time (TV/reading); Sleeping	Past year, on the usual day	5	F; D; I
Athens Physical Activity Questionnaire (APAQ) [76]	Adults, Greece	Occupational physical activity; Recreational physical activity; Home activities; Sleep; sedentary behaviour	Continuous: Times/week; hour/day; min/day	MI/day	Occupational physical activity; recreational physical activity; home activities	Past week	23	F; D
Sedentary Time and Activity Reporting Questionnaire (STAR-Q) [77]	Adults, USA	Eating; Personal/medical care; Sleep; Occupation; Transportation; Household; Yard work; Caregiving; Exercise; Light leisure; Stair-climbing; and “other” activities	Continuous: hour and min/day; number of times	For energy expenditure: Kcal/Day; For intensities: METs Hour/day	TEE, kcal/day; AEE, kcal/day; AEE, kcal/kg/day; Sleeping; Stair-climbing, flights/day; Active sitting; Overall activity (SB; LPA; MPA; VPA); Exercise, sports, and leisure activity (light, mod, vig); Occupational activity (sitting; sedentary behaviour; Light; Mod)	Past month	448	F; D; I; M

(Continued)

Table 2. (Continued)

Questionnaire	Age Group, Country	Domains	Response Method	Units of Measurement	Scores	Recall Period/ Assessment period	# Items	Parameters
Question 8 of the Paffenbarger Physical Activity Questionnaire (Q 8 PPAQ) [78]	Adults, USA	Total physical activity, sleep and sedentary behaviour	Continuous: hour/day	METs Hour/week; hour/day	Time spent sleeping or reclining, participating in sitting activities, and engaging in light (< 3 METs), MPA (3–6 METs), VPA (> 6 METs)	Usual day, on weekdays and weekend days	5	D; I
EPIC-Norfolk Physical Activity Questionnaire (EPAQ2) [79]	Adults, UK	Leisure; Sport; Occupational; household; Sleep duration	TV: 1–6 (none–>4h day); Stair climbing: 1–6 (None–>20 times/day); Household physical activity: 1–7 (None–>15 hour/week); Occup physical activity and sedentary behaviour-Continuous: hour/week; Stairs at work: 1–6 (none–>20 times/day; Kneeling and squatting: Dichotomous (kneeling and squatting > 1 hour; get up>30 times); Leisure physical activity: 1–8 (none–> 6 times/week) and continuous: hours and mins per episode); Sleep-Continuous: hour/day	hour/week; METs hour/week	TV time; Activity at work; Activity at home; Recreational activity; VPA; physical activity index	Past year, on weekdays and weekend days	87	F; D; M
Workers' sitting- and walking-time questionnaire Percentage Method (WSWQ—p-method) [66]	Adults, Japan	Occupational; Leisure; Sleep duration	Continuous: hours and min/day	Proportion of time (%)	Sitting and walking/standing during working time and non-working time; sitting and walking/standing during non-workday	Usual day on the last month	14	F; D
New Questionnaire on Physical Activity (NQPA) [80]	Adults and older adults, Netherlands	Total physical activity, sedentary behaviour, and sleep	Continuous: hours per day, week, or month	KJ/day	Rest; Occupational; Leisure Time	Past year	28	F; D; I
Web-Based Physical Activity Questionnaire (Active-Q) [81]	Adults and Older adults, Sweden	Leisure; Transportation; Occupational; Sport; Sleep	Transport-Rating scale: 1–5 (> 15 min–1–2 hours). Leisure activities-Rating scale: 1–6 (<30 mins–>8 hours. Sport—Rating scale: 1–5 (1–3 times/week–5–7 times/week); Rating scale: 1–5 (<30 mins–2–4 hours). Sleep: Rating scale: 1–6 (<5 hours–≥10 hours)	min/day	sedentary behaviour; LPA; sedentary behaviour + LPA; MPA; VPA; MVPA	Usual activity on the last months	47	F; D; M

(Continued)

Table 2. (Continued)

Questionnaire	Age Group, Country	Domains	Response Method	Units of Measurement	Scores	Recall Period/ Assessment period	# Items	Parameters
Flemish Physical Activity Computerized Questionnaire (FPACQ) [82]	Employed/unemployed adults, Belgium	Occupation; Transportation in leisure time; Watching television or video and playing computer games; Home and garden activities; Sleeping; MPA; VPA in leisure time; Sports participation	Continuous: hours per day or week; times per week or year; Kgs; Multiple choice	Kcal/Week: energy expenditure variables; hour/week: time variables	Time/week spent on sports participation; Energy expenditure/week on sports participation; Average energy expenditure on sports participation; Time/week spent eating; Time/week spent sleeping; Time/week spent watching television or videos or playing computer games; Time/week spent on leisure-time active transportation; Time/week spent on active leisure-time activities; Energy expenditure/week on active leisure time-activities; Average energy expenditure on active leisure-time activities; Time/week spent on occupation and transportation to and from occupation; Energy expenditure/week on occupation and transportation to and from occupation; Average energy expenditure on occupation and transportation to and from occupation; Overall energy expenditure during a usual week; physical activity level	Usual week	19	F; D
	Retired older adults, Belgium	Transportation in leisure time; Watching television or video and playing computer games; Home and garden activities; Sleeping; MPA and VPA in leisure time; sports participation					12	F; D

Abbreviations: n = Sample Number; SD = Standard Deviation; F = Frequency; D = Duration; I = Intensity; M = Mode; NA = Not Applicable; UK = United Kingdom; USA = United States of America; min = Minutes; MPA = Moderate Physical Activity; MVPA = Moderate to Vigorous Physical Activity; VPA = Vigorous physical activity; LPA = Light Physical Activity; TEE = Total Energy Expenditure; Kcal = Kilocalories.

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Table 3. Summary of results.

Questionnaire	Validity Quality		Reliability Quality	Measurement Error Quality	Content Validity Quality	Risk of bias			
	Criterion	Convergent				Validity		Reliability	Measurement Error
						Criterion	Convergent		
Physical Activity									
HUNT 1 [29]	-	-/-	+		+	1	1/1	3	N.R.
PYTPAQ [30]	-	-	-		+	1	1	1	N.R.
PAAT [31]	-	-	-		+	1	1	3	N.R.
Minnesota LTPA Q [32]	-	-/-	+		+	1	1/1	3	N.R.
SI PA M [33]	NA	-/-	-/+		-	NA	2/2	3	N.R.
Godin Q [32]	-	-/+	-		+	1	1/1	4	N.R.
CARDIA [32]	-	-/-	+		+	1	1/1	3	N.R.
College Alumnus Q [32]	-	-/-	-		-	1	1/1	3	N.R.
MHHP Q [32]	-	-/-	+		CD	1	1/1	3	N.R.
MHLAQ [34]	NA	-	+		CD	NA	1	2	N.R.
MV-AAS1 [35]	-	NA	-	?	CD	4	NA	4	2 (continuous scores, not reported)
MV-AAS2 [36]	-	NA	-	?	+	4	NA	4	4
Adapt AAS [37]	-	NA	-	?	+	4	NA	2	2 (continuous scores, not reported)
IPAQ-WS [38]	-	NA	-		+	1	NA	4	N.R.
SQUASH [39]	-	NA	-		+	1	NA	3	N.R.
EPIC PAQ [40]	-	-	-	?	+	4	1	3	1
13I-PAQ [41]	NA	-/-/-	+		+	NA	2/2/2	2	N.R.
QAPPA [42]	NA	-/-/-	-	?	+	NA	4/4/4	4	4
IPEQ [43]	NA	-	+		-	NA	4/4/4/4	2	N.R.
PAQ-EJ [44]	-	NA	-		+	4	NA	3	N.R.
LAPAQ [45]	-	NA	-	?	+	1	NA	3	1
NPAQ-short [46]	-	NA	-		+	1	NA	3	N.R.
SPAQ [47]	-	NA	+		-	1	NA	3	N.R.
TPAQ [48]	-	NA	-	?	-	1	NA	2	2
GPPAQ [49]	CD	NA	-	?	-	4	NA	4	4
Sedentary Behaviour									
IPAQ-SB [50]	-/-	NA	-/+		+	1	NA	3	N.R.
ALSWH—SB Q [51]	NA	-	-	?	+	NA	1	1	2
SBSW [52]	-	NA	-		+	1	NA	2	N.R.
SITBRQ [53]	-	NA	-	?	+	NA	NA	3	2
SBQ [54]	-	-	+		-	1	1	2	N.R.
SED-GIH [55]	-	NA	+		-	1	NA	4	N.R.
WSQ [56]	-	NA	-		CD	1	NA	1	N.R.
JSRM—SB [57]	-	NA	-		CD	1	NA	1	N.R.
LASA [58]	-	NA	+		+	1	NA	1	N.R.
YPAS-SB [59]	-	NA	-		+	1	NA	1	N.R.
CHAMPS-SB [59]	-	NA	-		+	1	NA	1	N.R.
CPS-3 ST [60]	-	NA	-		-	1	NA	3	N.R.
Sleep									
BRFSS Sleep [61]	CD	NA	CD		+	4	NA	4	N.R.

(Continued)

Table 3. (Continued)

Questionnaire	Validity Quality		Reliability Quality	Measurement Error Quality	Content Validity Quality	Risk of bias			
	Criterion	Convergent				Validity		Reliability	Measurement Error
						Criterion	Convergent		
Physical Activity + Sedentary Behaviour									
KPAS [62]	-	-/-	+		-	1	1	1	N.R.
STAQ [63]	-	-	-	?	+	1	1	1	2
IPAQ [64]	-/-/-/-	+/+	+/+/+/+	?	+	1	1	4	2 (continuous scores, not reported)
AWAS [65]	-	NA	-	?	+	1	NA	1	2
WSWQ- t-method [66]	-	NA	-		+	1	NA	1	N.R.
PASE [67]	NA	-/-/-/-	+		-	NA	1/1/1/1	4	N.R.
CHAMPS +transport [68]	-	NA	-		+	1	NA	4	N.R.
CHAMPS [69]	NA	-/-	-		+	NA	1/1	4	N.R.
Modified MOSPA-Q [70]	-	NA	-		+	1	NA	4	N.R.
OSPAQ [70, 71]	-/NA	NA/-	+/-		+	1/NA	NA/1	4/2	N.R./N.R.
RADI [72]	-	NA	-		-	1	NA	3	N.R.
GPAQ [73]	-	-	+		+	1	1	3	N.R.
Sedentary Behaviour + Sleep									
SIT-Q [74]	NA	-	-	?	+	NA	1	1	1
Physical Activity + Sedentary Behaviour + Sleep									
PAQ [75]	NA	-	-		-	NA	1	3	N.R.
APAQ [76]	+	NA	+	?	+	1	NA	2	2
STAR-Q [77]	NA	-	-		+	NA	1	1	N.R.
Q 8 PPAQ [78]	-	NA	-	?	+	1	NA	1	1
EPAQ2 [79]	-	-	-	?	-	1	1	3	4 (continuous scores, not reported)
WSWQ—p-method [66]	-	NA	+		+	1	NA	1	N.R.
NQPA [80]	NA	-	-	?	CD	NA	1	3	2
Active-Q [81]	-	NA	-		-	1	NA	1	N.R.
FPACQ [82]	-	NA	+	?	-	1	NA	1	2

Abbreviations:— = Inadequate; + = Adequate;? = Doubtful; NA = Not applicable; CD = Cannot be determined; N.R. = Not reported; 1 = Very low risk of bias; 2 = Low risk of bias; 3 = Medium risk of bias; 4 = High risk of bias.

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Regarding sleep, the BRFSS Sleep questionnaire [62] was evaluated against criterion and convergent measures; however, its validity quality could not be determined given that only Bland and Altman statistics were performed.

For the questionnaires combining PA and SB, none showed overall ‘adequate’ criterion validity. For these questionnaires, the accelerometer was the criterion measure in 75% of the questionnaires. Concerning criterion validity, the Sedentary, Transportation and Activity Questionnaire (STAQ) [64] questionnaire showed the best performance regarding the sitting time at work score (ICC = 0.82), when evaluated against accelerometry. The IPAQ’s short form, past and usual week versions, were rated with an ‘adequate’ overall convergent validity, when compared to the respective long forms [65].

The SIT-Q [75] was the only questionnaire combining SB and sleep and was evaluated against one convergent measure (e.g., Seven-Day Activity Diary). In this questionnaire, occupational SB was the only score with ‘adequate’ convergent validity ($\rho = 0.75$).

Concerning the questionnaires combining all movement behaviours, the APAQ [77] showed ‘adequate’ overall criterion validity against accelerometry for total energy expenditure ($\rho = 0.84$). The Sedentary Time and Activity Reporting Questionnaire (STAR-Q) [78] showed the best performance for convergent validity; this was assessed against a 7-day activity diary (energy expenditure $\rho = 0.74$; general occupational activity $\rho = 0.71$; occupational sitting $\rho = 0.75$; and SB $\rho = 0.75$).

3.2.4 Reliability and measurement error. Table 3 presents the summary of the results of the reliability and its details are provided in a supporting file [see S3 Table]. ‘Adequate’ overall reliability quality was observed in 37% of the questionnaires: seven PA questionnaires [30, 33, 42, 44, 48], four SB questionnaires [51, 55, 56, 59], eight questionnaires combining PA and SB [57, 63, 65, 68, 74], and three questionnaires combining PA, SB and sleep [67, 77, 83]. Sample characteristics for the reliability results were not specified in 42% of the studies. The time between test and retest ranged between two days to one year. The most often used statistical approaches to assess reliability were Pearson and Spearman correlations, ICCs, Kappa’s coefficients and percentages of agreement.

For measurement error, Bland and Altman plots comparing test and retest were applied in 31.7% of the questionnaires. Measurement error was calculated in 19 (out of 60) questionnaires and all were rated with ‘doubtful’ overall measurement error quality, because minimal important change was not reported (PA: four in adults [36–38, 41], two in older adults [43, 46] and two in both [49, 50]; SB: two in adults [52, 54]; PA and SB: three in adults [64–66]; SB and sleep: one in adults [75]; and PA, SB and sleep: three in adults [77, 79, 80]).

3.2.5 Responsiveness. The details on responsiveness are provided in a supporting file [see S4 Table]. Only one study (Community Healthy Activities Model Program for Seniors; CHAMPS) [69] evaluated responsiveness. The measures had small to moderate effect sizes (0.38 to 0.64), which resulted in an ‘adequate’ overall responsiveness quality, given that the results of the study were in accordance its hypothesis.

3.3 Risk of bias

Table 3 presents the summary of the results of risk of bias and its details are provided in a supporting file [see S5 Table]. The overall rating for risk of bias regarding criterion validity was very low for 72.2% of the studies. The main cause for high the risk of bias was the absence of sensitivity and specificity of dichotomous scores. For the overall reliability risk of bias, 23.6% of the studies were rated with a very low risk of bias. For the overall rating of measurement error risk of bias, 21.1% of the studies were classified with very low risk of bias. The main reasons for high the risk of bias for reliability or measurement error were the inappropriate interval between test and retest and the statistical methods used (e.g., correlations instead intra class correlations). For convergent validity, 82.4% of the studies were classified as having an overall very low risk of bias. The only study assessing responsiveness was rated with a medium risk of bias for this measurement property (CHAMPS) [70].

4. Discussion

This systematic review identified and described questionnaires assessing sleep, SB and PA or the combination of these movement behaviours, in adults and older adults.

We identified 60 questionnaires, describing content and measurement properties. Of these, 25 questionnaires measured PA, 12 SB, one sleep, 12 the combination of PA and SB, one the

combination of SB and sleep, and nine the combination of PA, SB, and sleep. Results showed high heterogeneity in the questionnaires' content, measurement properties and quality, which precluded a meta-analysis. Indeed, the questionnaires' content varied substantially in terms of behaviour's domain assessed, response method, measurement units, scores, recall and assessment periods, as well as, in the number of items and parameters evaluated.

The validity of the included questionnaires was mostly assessed by comparing the questionnaire with accelerometers, and the quality of validity results was frequently 'inadequate'. This could potentially be due to desirability bias or cognitive issues related to recall or comprehension of the questionnaires [9].

Only one questionnaire (APAQ) [77] measuring the combination of sleep, SB and PA showed 'adequate' overall quality for criterion validity. However, the validation results were only for total energy expenditure, which requires careful interpretation, because this outcome poses some limitations; as, the energy expenditure depends on other factors rather than movement behaviours (e.g., resting energy expenditure and thermic effect of food) [6]; accelerometry is not the most appropriate criterion measure to assess energy expenditure [6]; we cannot determine the results for each behaviour; and this is not a time-focused variable. In this sense, to assess a given movement behaviour, the actual time spent in it, seems to be a better output, which is the output generated by accelerometry. Although the limitations of accelerometry are well known, this still seems to be one of the best objective criterion measures to assess time spent in movement behaviours, in free living conditions [84]. Likewise, devices combining heart rate monitoring and accelerometry technologies to assess the intensity and time spent in different movement behaviours [6, 85] might also be adequate options for validation studies.

Regarding the reliability of the included questionnaires, there were different intervals between test and retest and the overall results' quality was also frequently 'inadequate'. However, these results are dependent on the number of scores that authors evaluated. For example, the PASE [68] was rated with an overall 'adequate' reliability; however, the authors only assessed the reliability for a single score; whereas in more complex questionnaires (i.e., with more scores), such as the WSQ [57], that presented 'adequate' reliability result in a general score (i.e., total, all domains ICC = 0.80), the overall quality was considered 'inadequate', due to the separated scores for reliability. Furthermore, the statistical procedures used by the different studies were often considered 'inadequate', mainly because Pearson or Spearman correlations were used instead of ICCs or Kappas, or because the time interval between test and retest was inappropriate. Indeed, despite Pearson and Spearman correlations do not have into account for systematic errors [29], these have been widely used in validity and reliability studies; however, it is well known that for continuous scores, ICCs are considered more appropriate, while for categorical scores, Kappas are advised [86]. For absolute validity by means and limits of agreement, Bland and Altman plots are recommended [87]; however, these were calculated only in a few of the included studies, either to report on validity or on reliability. Our findings largely contradict the conclusions of the studies included in this review, which considered that the questionnaire under study was valid and reliable, given that these studies used other metrics instead of the COSMIN quality criteria.

IPAQ [65] showed at simultaneously 'adequate' reliability and convergent validity, but not for criterion validity. For a questionnaire have an adequate validation, at least 'adequate' overall validity and reliability need to be attained, and a criterion measure is better than a convergent one to that purpose [21].

Responsiveness was only tested for CHAMPS [70]. Other reviews have also reported a lack of responsiveness assessment of questionnaires measuring PA [11, 19]. However, assessing

questionnaire's responsiveness is paramount to understand whether they are capable of measuring changes in movement behaviours over time [25].

Many questionnaires showed a high variability in content, together with inadequate measurement properties, which highlights the complexity of assessing the full spectrum of movement behaviours across the 24h period and reinforces the need for better self-reported questionnaires to measure movement behaviours combinations. The emergence of the 24h movement guidelines, due to its specific characteristics, raises the need to adapt or develop *de novo* instruments to assess 24h movement behaviours. The same concern has been raised regarding the new WHO PA and SB guidelines for adults [88].

The lack of questionnaires assessing 24h movement behaviours in an integrated way precludes accurate report of 24h movement behaviour guidelines' compliance and trends over time [89, 90], increases the risk of misclassification, and of biased and unreliable results [10]. Moreover, whilst new guidelines are developed and public health efforts to increase PA and decrease sedentary time proceed, measurement instruments should be improved; surveillance systems are adapted, and broadly and repeatedly implemented [91]. Indeed, measuring movement behaviours is complex and there is a need for better solutions, mainly to assess all movement behaviours in an integrated fashion. Given the measurement properties and the content of the questionnaires assessing a combination of all movement behaviours herein presented, there seems to be no single questionnaire capable to accurately measure these behaviours, considering the new 24h movement paradigm.

4.1 Limitations and strengths

We systematically reviewed existing questionnaires that measure all movement behaviours together or isolated, in adults and older adults. Comparing questionnaires' measurement properties is complex, given the heterogeneity of the data, including different scores, domains, variety of recall periods, comparison measures and reporting units. For example, the studies using accelerometry data to assess questionnaires' validity applied different epoch lengths, different definitions of (non)wear time and different placement sites. These aspects make comparisons between studies very difficult. Although the use of COSMIN guidelines should be considered a strength of this review, the COSMIN cut points to evaluate the quality of measurement properties may somewhat lead to loss of information, due to the mechanistic way of analysing data. Also, to the best of our knowledge, this review contains the largest sample of data/questionnaires assessing movement behaviours.

5. Conclusions

We systematically reviewed existing questionnaires that measure sleep, SB or PA, or their combination, in adults and older adults. There are several questionnaires with different characteristics and outputs for all movement behaviours. The included questionnaires presented frequent methodologic limitations, that resulted in inadequate validity and reliability scores. Existing questionnaires have insufficient measurement properties, and none was developed considering the 24h movement behaviour paradigm. The lack of valid and reliable questionnaires assessing 24h movement behaviours in an integrated way, precludes accurate monitoring and surveillance systems of 24h movement behaviours.

Supporting information

S1 Checklist. PRISMA 2020 checklist.
(DOCX)

S1 File. Search strategy.

(DOCX)

S2 File. Extracted information.

(DOCX)

S1 Table. Content validity table.

(DOCX)

S2 Table. Validity results.

(DOCX)

S3 Table. Reliability results.

(DOCX)

S4 Table. Responsiveness.

(DOCX)

S5 Table. Risk of bias.

(DOCX)

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4.2. Supplementary work

4.2.1. Supplementary work 1 - Search Strategy

PubMed

(exercise[Mesh] OR exercise [Title/Abstract] OR "physical activity" [Title/Abstract] OR "physical activities"[Title/Abstract] OR sedentary behavior[Mesh] OR "sedentary behavior [Title/Abstract] OR "sedentary behaviors" [Title/Abstract] OR "sedentary behaviour" [Title/Abstract] OR "sedentary behaviours" [Title/Abstract] OR "sitting position" [Mesh] OR "screen time" [Mesh] OR sedentar* [Title/Abstract] OR sleep [Mesh] OR sleep [Title/Abstract] OR "movement behavior*" [Title/Abstract] OR "movement behaviou*" [Title/Abstract] OR inactiv* [Title/Abstract])

AND

(surveys OR survey OR surveillance OR questionnaire OR questionnaires OR "proxy-reported" OR "proxy-report" OR "proxy-reports" OR "proxy report" OR "proxy reported" OR instrument OR instruments OR measur* OR scale OR scales OR assess* OR tool OR tools OR Interview* OR "self-report" OR "self-reported" OR "self-reports" OR "self report" OR "self reported" [Title/Abstract])

AND

(instrumentation[sh] OR methods[sh] OR "Validation Studies"[pt] OR "Comparative Study"[pt] OR "psychometrics"[MeSH] OR psychometr*[tiab] OR clinimetr*[tw] OR clinometr*[tw] OR "outcome assessment (health care)"[MeSH] OR "outcome assessment"[tiab] OR "outcome measure*" [tw] OR "observer variation"[MeSH] OR "observer variation"[tiab] OR "Health Status Indicators"[Mesh] OR "reproducibility of results"[MeSH] OR reproducib*[tiab] OR "discriminant analysis"[MeSH] OR reliab*[tiab] OR unreliab*[tiab] OR valid*[tiab] OR "coefficient of variation"[tiab] OR coefficient[tiab] OR homogeneity[tiab] OR homogeneous[tiab] OR "internal consistency"[tiab] OR (cronbach*[tiab] AND (alpha[tiab] OR alphas[tiab])) OR (item[tiab] AND (correlation*[tiab] OR selection*[tiab] OR reduction*[tiab])) OR agreement[tw] OR precision[tw] OR imprecision[tw] OR "precise values"[tw] OR test-retest[tiab] OR (test[tiab] AND retest[tiab]) OR (reliab*[tiab] AND (test[tiab] OR retest[tiab])) OR stability[tiab] OR interrater[tiab] OR inter-rater[tiab] OR intrarater[tiab] OR intra-rater[tiab] OR intertester[tiab] OR inter-tester[tiab] OR intratester[tiab] OR intra-tester[tiab] OR interobserver[tiab] OR inter-observer[tiab] OR intraobserver[tiab] OR intra-observer[tiab] OR intertechnician[tiab] OR inter-technician[tiab] OR intratechnician[tiab] OR intra-technician[tiab] OR interexaminer[tiab] OR inter-examiner[tiab] OR intraexaminer[tiab] OR intra-examiner[tiab] OR interassay[tiab] OR inter-assay[tiab] OR intraassay[tiab] OR intra-assay[tiab] OR interindividual[tiab] OR inter-individual[tiab] OR intraindividual[tiab] OR intra-individual[tiab] OR interparticipant[tiab] OR inter-participant[tiab] OR intraparticipant[tiab] OR intra-participant[tiab] OR kappa[tiab] OR kappa's[tiab] OR kappas[tiab] OR repeatab*[tw] OR ((replicab*[tw] OR repeated[tw]) AND (measure[tw] OR measures[tw] OR findings[tw] OR result[tw] OR results[tw] OR test[tw] OR tests[tw])) OR generaliza*[tiab] OR generalisa*[tiab] OR concordance[tiab] OR (intraclass[tiab] AND correlation*[tiab]) OR discriminative[tiab] OR "known group"[tiab] OR "factor analysis"[tiab] OR "factor analyses"[tiab] OR "factor structure"[tiab] OR "factor structures"[tiab] OR dimension*[tiab] OR subscale*[tiab] OR (multitrait[tiab] AND scaling[tiab] AND (analysis[tiab] OR analyses[tiab])) OR "item discriminant"[tiab] OR "interscale correlation*" [tiab] OR error[tiab] OR errors[tiab] OR "individual variability"[tiab] OR "interval variability"[tiab] OR "rate variability"[tiab] OR (variability[tiab] AND (analysis[tiab] OR values[tiab])) OR (uncertainty[tiab] AND (measurement[tiab] OR measuring[tiab])) OR "standard error of measurement"[tiab] OR sensitiv*[tiab] OR responsive*[tiab] OR (limit[tiab] AND detection[tiab]) OR "minimal detectable concentration"[tiab] OR interpretab*[tiab] OR ((minimal[tiab] OR minimally[tiab] OR clinical[tiab] OR clinically[tiab]) AND (important[tiab] OR significant[tiab] OR detectable[tiab]) AND

(change[tiab] OR difference[tiab])) OR (small*[tiab] AND (real[tiab] OR detectable[tiab]) AND (change[tiab] OR difference[tiab])) OR "meaningful change"[tiab] OR "ceiling effect"[tiab] OR "floor effect"[tiab] OR "Item response model"[tiab] OR IRT[tiab] OR Rasch[tiab] OR "Differential item functioning"[tiab] OR DIF[tiab] OR "computer adaptive testing"[tiab] OR "item bank"[tiab] OR "cross-cultural equivalence"[tiab])

PsycInfo

(exercise OR "physical activity" OR "physical activities" OR "sedentary behavior OR "sedentary behaviors" OR "sedentary behaviour" OR "sedentary behaviours" OR "sitting position" OR "screen time" OR sedentar* OR sleep OR "movement behavior*" OR "movement behaviou*" OR inactiv* OR bedtime OR bedtime* OR "time in bed")

AND

(surveys OR survey OR surveillance OR questionnaire OR questionnaires OR "proxy-reported" OR "proxy-report" OR "proxy-reports" OR "proxy report" OR "proxy reported" OR instrument OR instruments OR measur* OR scale OR scales OR assess* OR tool OR tools OR Interview* OR "self-report" OR "self-reported" OR "self-reports" OR "self report" OR "self reported" [Title/Abstract])

AND

("psychometrics" OR psychometr* OR clinimetr* OR clinometr* OR "outcome assessment" OR "outcome measure*" OR "observer variation" OR "observer variation" OR "Health Status Indicators" OR "reproducibility of results" OR reproducib* OR "discriminant analysis" OR reliab* OR unreliab* OR valid* OR "coefficient of variation" OR coefficient OR homogeneity OR homogeneous OR "internal consistency" OR (cronbach* AND (alpha OR alphas)) OR (item AND (correlation* OR selection* OR reduction*)) OR agreement OR precision OR imprecision OR "precise values" OR test-retest OR (test AND retest) OR (reliab* AND (test OR retest)) OR stability OR interrater OR inter-rater OR intrarater OR intra-rater OR intertester OR inter-tester OR intratester[tiab] OR intra-tester OR interobserver OR inter-observer OR intraobserver OR intra-observer OR intertechnician OR inter-technician OR intratechnician OR intra-technician OR interexaminer OR inter-examiner OR intraexaminer OR intra-examiner OR interassay OR inter-assay OR intraassay OR intra-assay OR interindividual OR inter-individual OR intraindividual OR intra-individual OR interparticipant OR inter-participant OR intraparticipant OR intra-participant OR kappa OR kappa's OR kappas OR repeatab* OR ((replicab* OR repeated) AND (measure OR measures OR findings OR result OR results OR test OR tests)) OR generaliza* OR generalisa* OR concordance OR (intraclass AND correlation*) OR discriminative OR "known group" OR "factor analysis" OR "factor analyses" OR "factor structure" OR "factor structures" OR dimension* OR subscale* OR (multitrait AND scaling AND (analysis OR analyses)) OR "item discriminant" OR "interscale correlation*" OR error OR errors OR "individual variability" OR "interval variability" OR "rate variability" OR (variability AND (analysis OR values)) OR (uncertainty AND (measurement OR measuring)) OR "standard error of measurement" OR sensitiv* OR responsive* OR (limit AND detection) OR "minimal detectable concentration" OR interpretab* OR ((minimal OR minimally OR clinical OR clinically) AND (important OR significant OR detectable) AND (change OR difference)) OR (small* AND (real OR detectable) AND (change OR difference)) OR "meaningful change" OR "ceiling effect" OR "floor effect" OR "Item response model" OR IRT OR Rasch OR "Differential item functioning" OR DIF OR "computer adaptive testing" OR "item bank" OR "cross-cultural equivalence")

CINHAL

(exercise OR "physical activity" OR "physical activities" OR "sedentary behavior OR "sedentary behaviors" OR "sedentary behaviour" OR "sedentary behaviours" OR "sitting position" OR

"screen time" OR sedentar* OR sleep OR "movement behavior*" OR "movement behaviour*" [Title/Abstract] OR inactiv* OR bedtime OR bedtime* OR "time in bed")

AND

(surveys OR survey OR surveillance OR questionnaire OR questionnaires OR "proxy-reported" OR "proxy-report" OR "proxy-reports" OR "proxy report" OR "proxy reported" OR instrument OR instruments OR measur* OR scale OR scales OR assess* OR tool OR tools OR Interview* OR "self-report" OR "self-reported" OR "self-reports" OR "self report" OR "self reported" [Title/Abstract])

AND

("psychometrics" OR psychometr* OR clinimetr* OR clinometr* OR "outcome assessment" OR "outcome measure*" OR "observer variation" OR "observer variation" OR "Health Status Indicators" OR "reproducibility of results" OR reproducib* OR "discriminant analysis" OR reliab* OR unreliab* OR valid* OR "coefficient of variation" OR coefficient OR homogeneity OR homogeneous OR "internal consistency" OR (cronbach* AND (alpha OR alphas)) OR (item AND (correlation* OR selection* OR reduction*)) OR agreement OR precision OR imprecision OR "precise values" OR test-retest OR (test AND retest) OR (reliab* AND (test OR retest)) OR stability OR interrater OR inter-rater OR intrarater OR intra-rater OR intertester OR inter-tester OR intratester [tiab] OR intra-tester OR interobserver OR inter-observer OR intraobserver OR intra-observer OR intertechnician OR inter-technician OR intratechnician OR intra-technician OR interexaminer OR inter-examiner OR intraexaminer OR intra-examiner OR interassay OR inter-assay OR intraassay OR intra-assay OR interindividual OR inter-individual OR intraindividual OR intra-individual OR interparticipant OR inter-participant OR intraparticipant OR intra-participant OR kappa OR kappa's OR kappas OR repeatab* OR ((replicab* OR repeated) AND (measure OR measures OR findings OR result OR results OR test OR tests)) OR generaliza* OR generalisa* OR concordance OR (intraclass AND correlation*) OR discriminative OR "known group" OR "factor analysis" OR "factor analyses" OR "factor structure" OR "factor structures" OR dimension* OR subscale* OR (multitrait AND scaling AND (analysis OR analyses)) OR "item discriminant" OR "interscale correlation*" OR error OR errors OR "individual variability" OR "interval variability" OR "rate variability" OR (variability AND (analysis OR values)) OR (uncertainty AND (measurement OR measuring)) OR "standard error of measurement" OR sensitiv* OR responsive* OR (limit AND detection) OR "minimal detectable concentration" OR interpretab* OR ((minimal OR minimally OR clinical OR clinically) AND (important OR significant OR detectable) AND (change OR difference)) OR (small* AND (real OR detectable) AND (change OR difference)) OR "meaningful change" OR "ceiling effect" OR "floor effect" OR "Item response model" OR IRT OR Rasch OR "Differential item functioning" OR DIF OR "computer adaptive testing" OR "item bank" OR "cross-cultural equivalence")

SportDiscus

(exercise OR "physical activity" OR "physical activities" OR "sedentary behavior" OR "sedentary behaviors" OR "sedentary behaviour" OR "sedentary behaviours" OR "sitting position" OR "screen time" OR sedentar* OR sleep OR "movement behavior*" OR "movement behaviour*" [Title/Abstract] OR inactiv* OR bedtime OR bedtime* OR "time in bed")

AND

(surveys OR survey OR surveillance OR questionnaire OR questionnaires OR "proxy-reported" OR "proxy-report" OR "proxy-reports" OR "proxy report" OR "proxy reported" OR instrument OR instruments OR measur* OR scale OR scales OR assess* OR tool OR tools OR Interview* OR "self-report" OR "self-reported" OR "self-reports" OR "self report" OR "self reported" [Title/Abstract])

AND

("psychometrics" OR psychometr* OR clinimetr* OR clinometr* OR "outcome assessment" OR
 "outcome measure*" OR "observer variation" OR "observer variation" OR "Health Status
 Indicators" OR "reproducibility of results" OR reproducib* OR "discriminant analysis" OR
 reliab*OR unreliab* OR valid* OR "coefficient of variation" OR coefficient OR homogeneity OR
 homogeneous OR "internal consistency"OR (cronbach* AND (alpha OR alphas)) OR (item AND
 (correlation* OR selection* OR reduction*)) OR agreement OR precision OR imprecision OR
 "precise values" OR test-retest OR (test AND retest) OR (reliab* AND (test OR retest)) OR
 stability OR interrater OR inter-rater OR intrarater OR intra-rater OR intertester OR inter-tester
 OR intratester[tiab] OR intra-tester OR interobserver OR inter-observer OR intraobserver OR
 intra-observer OR intertechnician OR inter-technician OR intratechnician OR intra-technician
 OR interexaminer OR inter-examiner OR intraexaminer OR intra-examiner OR interassay OR
 inter-assay OR intraassay OR intra-assay OR interindividual OR inter-individual OR
 intraindividual OR intra-individual OR interparticipant OR inter-participant OR intraparticipant
 OR intra-participant OR kappa OR kappa's OR kappas OR repeatab* OR ((replicab* OR
 repeated) AND (measure OR measures OR findings OR result OR results OR test OR tests))
 OR generaliza*OR generalisa* OR concordance OR (intraclass AND correlation*) OR
 discriminative OR "known group" OR "factor analysis" OR "factor analyses" OR "factor structure"
 OR "factor structures" OR dimension*OR subscale* OR (multitrait AND scaling AND (analysis
 OR analyses)) OR "item discriminant" OR "interscale correlation*" OR error OR errors OR
 "individual variability" OR "interval variability" OR "rate variability" OR (variability AND (analysis
 OR values)) OR (uncertainty AND (measurement OR measuring)) OR "standard error of
 measurement" OR sensitiv* OR responsive* OR (limit AND detection) OR "minimal detectable
 concentration" OR interpretab* OR ((minimal OR minimally OR clinical OR clinically) AND
 (important OR significant OR detectable) AND (change OR difference)) OR (small* AND (real
 OR detectable) AND (change OR difference)) OR "meaningful change" OR "ceiling effect" OR
 "floor effect" OR "Item response model" OR IRT OR Rasch OR "Differential item functioning" OR
 DIF OR "computer adaptive testing" OR "item bank" OR "cross-cultural equivalence")

4.2.2. Supplementary work 2 – Extracted information

For the content description, we extracted information on the name of the questionnaire:

1 - Age group and country: If the questionnaire was validated in adults, older adults, or both.

2 - Domains: Which domains the questionnaire refers to (e.g., leisure, occupational, transportation, etc.). When there was no distinction between domains, we reported total sleep/ sedentary behaviour/physical activity.

- Response method: What kind of response the questionnaire allows for (e.g., rating scale or continuous response).

- Measurement units: Which unit the researchers must use to evaluate the movement behaviours (e.g., METs, minutes/day; hours/week, etc.).

- Scores: What are the final outputs from the questionnaire (e.g., total sleep/ sedentary behaviour/physical activity; sleep duration; occupational physical activity/ sedentary behaviour, activity level index, etc.).

- Recall period/Assessment period: To which period the questionnaire refers to (e.g., typical/last day/week, on week and weekend or whole day/week without distinction for the types of days, etc.);

- Number of items: How many items compose the questionnaire.

- Parameters: Frequency, duration, intensity and mode.

For the measurement properties, we extracted information about:

Sample size and demographic characteristics (e.g., gender and age).

Validity: The degree to which an instrument truly measures the construct(s) that wants to measure, free from all possible sources of error or bias.

Type of validity: Criterion (e.g., the extent of the correlation between a measure and another already considered as being a criterion or gold standard) or convergent (e.g., the extent of the agreement with another (non-criterion) measure that should assess the same behaviour parameter based on face and content validity).

Comparison measure: Which instrument was used to validation (e.g., accelerometer, another questionnaire, etc.).

Results: Validity results per variable (e.g., pearson/spearman correlations, Bland Altman, etc.).

– Quality of study: Explained below.

Reliability:

Time between test and retest.

Results: Pearson and Spearman correlations, intraclass correlations, kappas, measurement error (e.g., limits of agreement, etc.).

Responsiveness:

Type of responsiveness. Results: Effect tests, etc.

4.2.3. Supplementary work 3 - Content validity

Table S1. Content Validity Results

Questionnaire	1.Questionnaire integrated in paper?	2.Questionnaire found in other source? Which one?	3.At least 85% of the items are relevant for the construct of interest.	4.At least 85% of the items are relevant for the population of interest.	5.At least 85% of the items are relevant for the context of use of interest.	6.At least 85% of the response options are appropriate for the construct, population, and context of use of interest.	7.The recall period is appropriate for the construct, population, and context of use of interest.	8.The questionnaire is comprehensive for the construct, population and context of use of interest.	9.At least 85% of the items and response options are appropriately worded.	10.At least 85% of the response options match the questions.	Overall Rating
Physical Activity											
Nord-Trøndelag Health Study PA Questionnaire (HUNT 1) ³⁰	+	NA	+	+	+	+	+	+	+	+	+
Past Year Total Physical Activity Questionnaire (PYTPAQ) ³¹	No	Yes, DAPA	+	+	+	+	+	+	+	+	+
Physical Activity Assessment Tool (PAAT) ³²	+	NA	+	+	+	+	+	+	+	+	+
Minnesota Leisure Time Physical Activity Questionnaire (Minnesota LTPA Q) ³³	No	Yes, internet	+	+	+	+	+	+	+	+	+
Single Item Physical Activity Measure (SI	+	NA	+	+	+	-	+	+	+	+	-

PA M) ³⁴												
Godin Questionnaire (Godin Q) ³³	No	Yes, internet	+	+	+	+	+	+	+	+	+	+
CARDIA Physical Activity History (CARDIA) ³³	No	Yes, internet	+	+	+	+	+	+	+	+	+	+
College Alumnus Questionnaire (College Alumnus Q) ³³	No	Yes, internet	+	+	+	-	+	+	+	+	+	-
Minnesota Heart Health Program Questionnaire (MHHP Q) ³³	No	No										CD
Modified Historical Leisure Activity Questionnaire (MHLAQ) ³⁵	No	No										CD
Modified version Active Australia Survey 1(MV – AAS1) ³⁶	No	No										CD
Modified version Active Australia Survey (MV – AAS2) ³⁷	+	NA	+	+	+	+	+	+	+	+	+	+
Adapted from Active Australia Survey (Adapt AAS) ³⁸	+	NA	+	+	+	+	+	+	+	+	+	+
International Physical Activity Questionnaire – Walking Section (IPAQ-WS) ³⁹	+	NA	+	+	+	+	+	+	+	+	+	+
Short Questionnaire to Assess Health-enhancing physical	+	NA	+	+	+	+	+	+	+	+	+	+

activity (SQUASH) ⁴⁰												
European Prospective Investigation into Cancer and Nutrition Physical Activity Questionnaire (EPIC PAQ) ⁴¹	+	NA	+	+	+	+	+	+	+	+	+	+
13-Item Physical Activity Questionnaire (13I-PAQ) ⁴²	+	NA	+	+	+	+	+	+	+	+	+	+
Questionnaire d'Activité Physique pour les Personnes Âgées (QAPPA) ⁴³	+	NA	+	+	+	+	+	+	+	+	+	+
Incidental and Planned Exercise Questionnaire (IPEQ) ⁴⁴	+	NA	+	+	+	+	+	+	+	+	+	+
Physical Activity Questionnaire for Elderly Japanese (PAQ-EJ) ⁴⁵	+	NA	+	+	+	+	+	+	+	+	+	+
The Longitudinal Ageing Study Amsterdam Physical Activity Questionnaire (LAPAQ) ⁴⁶	+	NA	+	+	+	+	+	+	+	+	+	+
Nordic Physical Activity Questionnaire (NPAQ-short) ⁴⁷	+	NA	+	+	+	+	+	+	+	+	+	+
Self-report physical activity questionnaire (SPAQ) ⁴⁸	+	NA	+	+	+	+	+	+	+	+	+	+

Transport and Physical Activity Questionnaire (TPAQ) ⁴⁹	+	NA	+	+	+	+	+	+	+	+	+
General Practice Physical Activity Questionnaire (GPPAQ) ⁵⁰	+	NA	+	+	+	-	+	+	+	+	-
Sedentary Behaviour											
International Physical Activity Questionnaire - Sedentary Behavior (IPAQ-SB) ⁵¹	+	NA	+	+	+	+	+	+	+	+	+
Australian Longitudinal Study on Women's Health - Sedentary Behavior Questions (ALSWH - SB Q) ⁵²	+	NA	+	+	+	+	+	+	+	+	+
Self-reported sitting and breaks from sitting in the workplace (SBSW) ⁵³	+	NA	+	+	+	+	+	+	+	+	+
Workplace Sitting Breaks Questionnaire (SITBRQ) ⁵⁴	+	NA	+	+	+	+	+	+	+	+	+
Sedentary Behavior Questionnaire (SBQ) ⁵⁵	No	Yes, sent by author	+	+	+	-	+	+	+	+	-
SED-GIH ⁵⁶	+	NA	+	+	+	-	+	+	+	+	-
Workforce Sitting Questionnaire (WSQ) ⁵⁷	No	No									CD
Japanese-Language Self-reported Measures for Assessing Adults	No	Yes, sent by author	+	+	+	+	+	+	+	+	CD

Domain-Specific Sedentary Time (JSRM - SB) ⁵⁸											
Longitudinal Aging Study Amsterdam questionnaire (LASA) ⁵⁹	+	NA	+	+	+	+	+	+	+	+	+
SB question of the Yale Physical Activity Survey (YPAS - SB) ⁶⁰	No	Yes, internet	+	+	+	+	+	+	+	+	+
Community Health Activities Model Program for Seniors SB questions (CHAMPS - SB) ⁶⁰	No	Yes, internet	+	+	+	+	+	+	+	+	+
Cancer Prevention Study-3 Sedentary Time Survey (CPS-3 sitting time) ⁶¹	+	NA	+	+	+	-	+	+	+	+	-
Sleep											
BRFSS sleep questions (BRFSS Sleep) ⁶²	+	NA	+	+	+	+	+	+	+	+	+
Physical Activity + Sedentary Behaviour											
Kaiser Physical Activity Survey (KPAS) ⁶³	+	NA	+	+	+	-	+	+	+	+	-
Sedentary, Transportation and Activity Questionnaire (STAQ) ⁶⁴	+	NA	+	+	+	+	+	+	+	+	+
International Physical Activity Questionnaire (IPAQ) ⁶⁵	+	NA	+	+	+	+	+	+	+	+	+

Australian Women's Activity Survey (AWAS) ⁶⁶	+	NA	+	+	+	+	+	+	+	+	+	+
Workers' sitting- and walking-time questionnaire Time Method (WSWQ- t-method) ⁶⁷	+	NA	+	+	+	+	+	+	+	+	+	+
The Physical Activity Scale for the Elderly (PASE) ⁶⁸	No	Yes, internet	+	+	+	-	+	+	+	+	+	-
Community Health Activities Model Program for Seniors physical activity self-report questionnaire + transport items (CHAMPS+transport) ⁶⁹	No	Yes, sent by author	+	+	+	+	+	+	+	+	+	+
Community Healthy Activities Model Program for Seniors (CHAMPS) ⁷⁰	+	NA	+	+	+	+	+	+	+	+	+	+
Modified Version of the MONICA Optional Study on Physical Activity Questionnaire (Modified MOSPA-Q) ⁷¹	+	NA	+	+	+	+	+	+	+	+	+	+
Occupational Sitting and Physical Activity Questionnaire (OSPAQ) ^{71,72}	+	NA	+	+	+	+	+	+	+	+	+	+
Rapid Assessment Disuse Index (RADI) ⁷³	No	Yes, internet	+	+	+	-	+	+	+	+	+	-

Global Physical Activity Questionnaire (GPAQ) ⁷⁴	+	NA	+	+	+	+	+	+	+	+	+
Sedentary Behaviour + Sleep											
SIT-Q ⁷⁵	+	NA	+	+	+	+	+	+	+	+	+
Physical Activity + Sedentary Behaviour + Sleep											
Physical Activity Questionnaire (PAQ) ⁷⁶	+	NA	+	+	+	-	+	+	+	+	-
Athens Physical Activity Questionnaire (APAQ) ⁷⁷	+	NA	+	+	+	+	+	+	+	+	+
Sedentary Time and Activity Reporting Questionnaire (STAR-Q) ⁷⁸	+	NA	+	+	+	+	+	+	+	+	+
Question 8 of the Paffenbarger Physical Activity Questionnaire (Q 8 PPAQ) ⁷⁹	+	NA	+	+	+	+	+	+	+	+	+
EPIC-Norfolk Physical Activity Questionnaire (EPAQ2) ⁸⁰	+	NA	+	+	+	-	+	+	+	+	-
Workers' sitting- and walking-time questionnaire Percentage Method (WSWQ - p-method) ⁶⁷	+	NA	+	+	+	+	+	+	+	+	+
New Questionnaire on Physical Activity (NQPA) ⁸¹	No	No									CD
Web-Based Physical Activity Questionnaire	No	Yes, internet	+	+	+	-	+	+	+	+	-

(Active-Q)⁸²

Flemish Physical Activity Computerized Questionnaire (FPACQ) ⁸³	+	NA	+	+	+	-	+	+	+	+	-

Abbreviations: NA = Not Applicable; CD = Cannot be determined; DAPA = Diet, Anthropometry and Physical Activity (DAPA) Measurement Toolkit; + = Adequate; - = Inadequate

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4.2.4. Supplementary work 4 - Validity results

Table S2. Validity Results

Questionnaire	Sample	Validity			Quality of validity results	Overall Quality	
	n; % Women; Age mean $\pm$ SD or Age range (years)	Type of Validity	Comparison Measure	Results			
Physical Activity							
Nord-Trøndelag Health Study PA Questionnaire (HUNT 1) ³⁰	108 men; 20 - 39 yrs	Criterion	Accelerometer (ActiReg), 7 days on hip	Frequency $\rho = 0.03$	-	-	
				Intensity $\rho = 0.06$	-		
				Duration $\rho = 0.12$	-		
				Index $\rho = 0.07$	-		
				1-3 METs $\rho = -0.06$	-		
				3-6 METs 6+ $\rho = 0.32^*$	-		
		Convergent	IPAQ	Frequency:			-
				IPAQ Total VPA $\rho = 0.44^{**}$	-		
				IPAQ Total MPA $\rho = 0.31^{**}$	-		
				IPAQ Walking $\rho = 0.26^{**}$	-		
				IPAQ METs $\rho = 0.28^*$	-		
				Intensity:			
				IPAQ Total VPA $\rho = 0.49^{**}$	-		

Past Year Total Physical Activity Questionnaire (PYTPAQ) ³¹	154; 51% women, 48.7 ± 7.7 yrs	Criterion	Accelerometer (Actigraph), 7 days, minute-by-minute observations of whole-body motion, on waist.	Vo2max	IPAQ Total MPA $\rho = 0.18$	-	
					IPAQ Walking $\rho = 0.18$	-	
					IPAQ METs $\rho = 0.32^{**}$	-	
					Duration:		
					IPAQ Total VPA $\rho = 0.41^{**}$	-	
					IPAQ Total MPA $\rho = 0.21^*$	-	
					IPAQ Walking $\rho = 0.06$	-	
					IPAQ METs $\rho = 0.20$	-	
					Index:		
					IPAQ Total VPA $\rho = 0.55^{**}$	-	
					IPAQ Total MPA $\rho = 0.30^*$	-	
					IPAQ Walking $\rho = 0.18$	-	
					IPAQ METs $\rho = 0.32^{**}$	-	
					Frequency $\rho = 0.43^*$	-	-
					Intensity $\rho = 0.40^*$	-	
					Duration $\rho = 0.31^*$	-	
					Index $\rho = 0.48^*$	-	
					Total population $\rho = 0.26^*$;	-	-
					<50 yr $\rho = 0.43^{**}$; >50 yr = 0.05	-	

		Convergent	7-day physical activity log	Total population $\rho = 0.41^{***}$;	-	-
				<50 yr $\rho = 0.53^{**}$; >50 yr = 0.26*	-	
Physical Activity Assessment Tool (PAAT) ³²	63; N.R.; N.R.	Criterion	Accelerometer (Actigraph, MTI) on waist	MVPA $\rho = 0.39^{**}$	-	-
				MPA $\rho = 0.39^{**}$	-	
				VPA $\rho = 0.38^{**}$	-	
				Activity level agreement = 69.8%; $\kappa = 0.34$	-	
				Sensitivity and Specificity = 71.1% and 66.7%		
				Positive Predictive Value = 84.2%		
				Negative Predictive Value = 48.0%		
		Convergent	IPAQ	MVPA $r = 0.59^{***}$	-	-
				Activity level agreement = 66.7%; $\kappa = 0.21$	-	
Minnesota Leisure Time Physical Activity Questionnaire (Minnesota LTPA Q) ³³	73; N.R.; N.R.	Criterion	Accelerometer (Caltrac), 2 days on hip	Total Leisure time physical activity $\rho = 0.18$	-	-
				LPA $\rho = 0.07$	-	
				MPA $\rho = 0.22$	-	
				VPA $\rho = 0.16$	-	
				Household chores $\rho = 0.03$	-	
		Convergent	4-week history	Total Leisure time physical activity $\rho = 0.74$	-	-
				LPA $\rho = 0.13$	-	
				MPA $\rho = 0.25$	-	

				VPA $\rho = 0.52$	-	
				Household chores $\rho = 0.55$	-	
			Vo2max	Total Leisure time physical activity $\rho = 0.43$	-	-
				LPA $\rho = 0.11$	-	
				MPA $\rho = 0.15$	-	
				VPA $\rho = 0.39$	-	
				Household chores $\rho = 0.18$	-	
Single Item Physical Activity Measure (SI PA M) ³⁴	522; N.R.; N.R.	Convergent	Global Physical Activity Questionnaire	Physical activity week (past week question) $\rho = 0.53$	-	-
			Active People Survey	Physical activity month (past month question) $\rho = 0.48$	-	-
Godin Questionnaire (Godin Q) ³³	73; N.R.; N.R.	Criterion	Accelerometer (Caltrac), 2 days on hip	Leisure score $\rho = 0.32$	-	-
		Convergent	4-week history	Leisure score $\rho = 0.36$	-	-
	64; N.R.; N.R.		Vo2max	Leisure score $\rho = 0.56$	-	-
CARDIA Physical Activity History (CARDIA)(Jacobs et al., 1993)	73; N.R.; N.R.	Criterion	Accelerometer (Caltrac), 2 days on hip	MPA $\rho = 0.11$	-	-
				VPA $\rho = 0.31$	-	
		Convergent	4-week history	MPA $\rho = 0.08$	-	-
				VPA $\rho = 0.54$	-	
	64; N.R.; N.R.		Vo2max	MPA $\rho = 0.08$	-	-
				VPA $\rho = 0.63$	+	
College Alumnus Questionnaire (College	73; N.R.; N.R.	Criterion	Accelerometer (Caltrac), 2 days on hip	Total index $\rho = 0.30$	-	-

Alumnus Q)³³

				Stairs $\rho = -0.01$	-	
				Blocks $\rho = 0.16$	-	
		Convergent	4-week history	Total index $\rho = 0.31$	-	-
				Stairs $\rho = 0.25$	-	
				Blocks $\rho = 0.06$	-	
	64; N.R.; N.R.		Vo2máx	Total index $\rho = 0.52$	-	-
				Stairs $\rho = 0.02$	-	
				Blocks $\rho = -0.01$	-	
Minnesota Heart Health Program Questionnaire (MHHP Q) ³³	73; N.R.; N.R.	Criterion	Accelerometer (Caltrac), 2 days on hip	Work index $\rho = 0.04$	-	-
				Leisure index $\rho = 0.28$	-	
		Convergent	4-week history	Work index $\rho = -0.09$	-	-
				Leisure index $\rho = 0.39$	-	
			Vo2max	Work index $\rho = 0.00$	-	-
				Leisure index $\rho = 0.56$	+	
Modified Historical Leisure Activity Questionnaire (MHLAQ) ³⁵	131; 100 % women; 50.4 $\pm$ 7.6 yrs	Convergent	Physical activity log	<50 yr:		-
				Total physical activity $r = 0.31^*$	-	
				MPA $r = 0.16$	-	
				VPA $r = 0.58^{**}$	-	

				>50 yr:		
				Total physical activity $r = 0.19$	-	
				MPA $r = 0.12$	-	
				VPA $r = 0.47^{**}$	-	
Modified version Active Australia Survey 1(MV – AAS1) ³⁶	159; 100% women; 54-59yrs	Criterion	Pedometer	walking $\rho=0.29^{***}$	-	-
				Total physical activity $\rho=0.43^{***}$	-	
Modified version Active Australia Survey (MV – AAS2) ³⁷	63; 63% women; 49.5 ± 12.5 yrs	Criterion	Accelerometer (MTI Model 7164), on hip	Mins/week MPA $\rho= 0.50$ (95% CI: 0.28 to 0.66)	-	-
				Mins/week VPA $\rho= 0.60$ (95% CI: 0.41 to 0.74)	-	
				Mins/week MVPA $\rho= 0.61$ (95% CI: 0.43 to 0.75)	-	
				Days/week MPA $\kappa = 0.35$ (95% CI: 0.10 to 0.50)	-	
				Days/week VPA $\kappa= 0.61$ (95% CI: 0.29 to 0.87)	-	
				Days/week MVPA $\kappa= 0.45$ (95% CI: 0.34 to 0.66)	-	
				Bland-Altman: $LoA= 22.60 \pm 69.94 + 1.01 \times$ average Australian Active Survey & accelerometer).		
Adapted from Active Australia Survey (Adapt AAS) ³⁸	122; 53% women; 38 ± 15 yrs	Criterion	Accelerometer (MTI Model 7164), on hip	Mins/day men MPA $\rho=0.40^{**}$	-	-
				Mins/day men VPA $\rho= 0.19$	-	
				Mins/day men MVPA $\rho= 0.29^*$	-	

International Physical Activity Questionnaire – Walking Section (IPAQ-WS) ³⁹	247; 55% women; 23-57 yrs	Criterion	Accelerometer (Actigraph), 5 days	Mins/day women MPA $\rho = 0.19$	-	
				Mins/day women VPA $\rho = 0.10$	-	
				Mins/day women MVPA $\rho = 0.25^*$	-	
				Past week walking $\rho = 0.39$	-	-
				Past week walk+MPA $\rho = 0.24$	-	
				Usual week walk+MPA $\rho = 0.04$	-	
				Usual week walking $\rho = 0.26$	-	
Short Questionnaire to Assess Health-enhancing physical activity (SQUASH) ⁴⁰	50; 28% women; 44 $\pm$ 6 yrs	Criterion	Accelerometer, (CSA Inc. model AM7164-2.2), 1 min epoch, 2 weeks, on waist	Activity levels $\rho = 0.45^*$ (95% CI: 0.17 to 0.66)	-	-
				Tertiles of the activity score $\rho = 46\%$; weighed κ was 0.30	-	
European Prospective Investigation into Cancer and Nutrition Physical Activity Questionnaire (EPIC PAQ) ⁴¹	182; 45% women; 50-65 yrs	Criterion	Accelerometer (Actigraph), 7 days	Total non-occup physical activity $\rho = 0.21^{**}$ (95% CI: 0.07 to 0.35)	-	-
				VPA (self-rated) $\rho = 0.18^*$ (95% CI: 0.04 to 0.32)	-	
				VPA (MET-assigned) $\rho = 0.23^{**}$ (95% CI: 0.09 to 0.37)	-	
				LPA to MPA $\rho = 0.19^{**}$ (95% CI: 0.05 to 0.33)	-	
				Bland Altman: Mean difference: 66.4 $\pm$ 67.9; 95% LoA: -66.7 to 199.6		
		Convergent	Friedenreich LTPAQ	Total non-occup physical activity $\rho = 0.26^{***}$ (0.11 to 0.39)	-	-

13-Item Physical Activity Questionnaire (13I-PAQ) ⁴²	54, N.R.	Convergent		VPA $\rho = 0.40^{***}$ (95% CI: 0.27 to 0.52)	-
				LPA to MPA $\rho = 0.26^{***}$ (95% CI: 0.12 to 0.39)	-
				Household physical activity $\rho = 0.46^{***}$ (95% CI: 0.34 to 0.57)	-
				Recreational physical activity $\rho = 0.21^*$ (95% CI: 0.07 to 0.34)	-
			Women		-
			Body Fat	Total physical activity $r = -0.73^*$	+
				Sport $r = -0.55^*$	+
				LTPA $r = 0.06$	-
			VO2Max	Occupational and household physical activity $r = -0.53^*$	+
				Total physical activity $r = 0.63^*$	+
				Sport $r = 0.67^*$	+
			Flexibility	LTPA $r = -0.14$	-
				Occupational and household physical activity $r = 0.27$	-
				Total physical activity $r = 0.28$	-
				Sport $r = 0.18^*$	-
			Body Fat	LTPA $r = 0.25$	-
				Occupational and household physical activity = 0.02	-
				Men	
			Body Fat	Total physical activity $r = -0.46^*$	-

			Sport $r = -0.43^*$	-
			LTPA $r = 0.10$	-
			Occupational and household physical activity = -0.16	-
VO2Max			Total physical activity $r = 0.57^*$	+
			Sport $r = 0.67^*$	-
			LTPA $r = 0.09$	-
			Occupational and household physical activity $r = 0.04$	-
Flexibility			Total physical activity $r = 0.39^*$	-
			Sport $r = 0.39^*$	-
			LTPA $r = 0.19$	-
			Occupational and household physical activity = 0.06	-
Questionnaire d'Activité Physique pour les Personnes Âgées (QAPPA) ⁴³	393; 64.1% women; 70.1 ± 8 yrs	Convergent	Moderate (METM):	-
			Questionnaire (exercise behaviour [yes/no] in the last 2 months)	Significant difference between exercisers and non-exercisers (Wilcoxon rank sum test)
			Satisfaction with body functioning	$\rho = 0.16^{**}$ -
			Decline in physical function	$\rho = -0.21^{**}$ -

Incidental and Planned Exercise Questionnaire (IPEQ) ⁴⁴			Age	$\rho = -0.13^{**}$.	-	
				Vigorous (METV):		
			Questionnaire (exercise behaviour [yes/no] in the last 2 months)	Significant difference between exercisers and non-exercisers (Wilcoxon rank sum test)		
			Satisfaction with body functioning	$\rho = 0.39^{**}$	-	
			Decline in physical function	$\rho = -0.32^{**}$	-	
			Age	$\rho = -0.30^{**}$	-	
				Moderate-to-vigorous (METT):		
			Questionnaire (exercise behaviour [yes/no] in the last 2 months)	Significant difference between exercisers and non-exercisers (Wilcoxon rank sum test)		
			Satisfaction with body functioning	$\rho = 0.45^{**}$	-	
			Decline in physical function	$\rho = -0.40^{**}$	-	
			Age	$\rho = -0.29^{**}$.	-	
			Classification (active/inactive):	Significant difference between exercisers and non-exercisers (Chi-squared test)		
			IPEQ-3 months vs IPEQ-Week (n = 50)	Total (hours per week) $\rho = 0.67$;	-	-
	IPEQ- 3 months n = 230; 54% women; N.R.	Convergent				
	IPEQ-Week n = 270; 57% women; N.R.	Convergent		Total (hours of planned and incidental physical activity per week) $\rho = 0.73$	+	

			WHODAS	Planned physical activity (both versions); Incidental physical activity (IPEQ-Week); Significant difference between score >20		
			Time up-and-go	Planned physical activity (both versions); Significant difference between time>10 seconds		
			Age	Planned physical activity (both versions); Significant difference between age >75		
			Accelerometer, on waist, 1 month, 4 seconds	Total PAQ-EJ rank-ordered r (month averaged daily step count) = 0.41	-	-
Physical Activity Questionnaire for Elderly Japanese (PAQ- EJ) ⁴⁵	147; 58.5% women; 65-85 yrs	Criterion		Subtotal of lower intensity activity categories (objective month-averaged record for the daily duration of physical activity <3 METs) r = 0.28	-	
				Subtotal of higher intensity activity categories (objective measurements for the duration of activity $\geq$ 3 METs) r = 0.53	-	
				Total physical activity r = 0.25 (95% CI: 0.07 to 0.44)	-	-
				$\geq$ 6 METs r = 0.01 (95% CI: -0.07 to -0.25)	-	
				3-5.99 METs r = 0.27 (95% CI: 0.07 to 0.25)	-	
				2-2.99 METs r = 0.05 (95% CI: -0.16 to -0.24)	-	
				The Bland–Altman plot shows much spread around the regression line and the range between the limits of agreement is wide, indicating measurement error in the LAPAQ		
				ROC curve: AUC = 0.73 (95% CI 0.59 to 0.86)	+	
The Longitudinal Ageing Study Amsterdam Physical Activity Questionnaire (LAPAQ) ⁴⁶	88; 52% women; 65–88 yrs	Criterion	Accelerometer (Sensewear® Pro Armband Accelerometer BodyMedia, Inc), on arm			

Nordic Physical Activity Questionnaire (NPAQ-short) ⁴⁷	92; N.R.; N.R.	Criterion	Accelerometer (Actiheart), 60 seconds epoch, on chest	MVPA open questions weighted $\kappa = 0.17$ (95% CI: 0.07 to 0.30) - - MVPA close questions weighted $\kappa = 0.20$ (95% CI: 0.07 to 0.36) - VPA open questions weighted $\kappa = 0.21$ (95% CI: 0.08 to 0.37) - VPA close questions weighted $\kappa = 0.20$ (95% CI: 0.06 to 0.34) - Compliance with WHO guidelines κ (open questions) = 0.42 (95% CI: 0.19 to 0.65); Specificity = 50%; Sensitivity = 90% - Compliance with WHO guidelines κ (close questions) = 0.34 (95% CI: 0.12 to 0.56); Specificity = 55%; Sensitivity = 81% - Compliance with WHO guidelines κ (both questions' type) = 0.37 (95% CI: 0.14 to 0.61); Specificity = 40%; Sensitivity = 98% - Bland-Altman: MVPA mean difference: - 111 min (LoA: - 680 to 457) Bland-Altman: VPA min difference: 26 min (LoA: -173 to -224)	
Self-report physical activity questionnaire (SPAQ) ⁴⁸	150; 73.3% women; 60-over 80 yrs	Criterion	Accelerometer (Actigraph), on hip	Activity counts/week: - Total physical activity $r = 0.31^{**}$ - LPA $r = 0.24^{**}$ - MPA $r = 0.31^{**}$ - Household physical activity $r = 0.19^*$ - Occupational physical activity $r = 0.19^*$ -	

				Leisure time recreation $r = 0.18^{**}$	-	
				Leisure time exercise $r = 0.24^{**}$	-	
				Transportation physical activity $r = 0.20^*$	-	
				Total MET hour/week:		
				LPA $r = 0.90^{**}$	+	
				MPA $r = 0.87^{**}$	+	
				Household physical activity $r = 0.83^{**}$	+	
				Occupational physical activity $r = 0.31^{**}$	-	
				Leisure time recreation $r = 0.52^{**}$	-	
				Leisure time exercise $r = 0.69^{**}$	-	
				Transportation physical activity $r = 0.56^{**}$	-	
Transport and Physical Activity Questionnaire (TPAQ) ⁴⁹	54; 64.8% female, <30 - ≥65 yrs	Criterion	Accelerometer (Actigraph GT3X), 10 seconds epoch, 7 days on hip	MPA $\rho = 0.24$	-	-
				VPA $\rho = 0.72^{***}$	+	
				MVPA $\rho = 0.27^*$	-	
				MPA including cycling $\rho = 0.10$	-	
				MVPA including cycling $\rho = 0.09$	-	
				Bland-Altman: A mean overestimation of self-reported MVPA of 87.6 min/week ($p = 0.02$) was observed and the 95% limits of agreement were wide (2447.1 to +622.3 min/week)		
General Practice Physical Activity Questionnaire	298; 54% women; 60-74	Criterion	Accelerometer (Actigraph GT3X+), 5	Agreement of achieving guidelines = 24%		

(GPPAQ) ⁵⁰	yrs	seconds epochs	Categorical Achievement: GPPAQ Inactive = 53% GPPAQ Moderately inactive = 12 % GPPAQ Moderately active = 19% GPPAQ Active = 16% Sensitivity of GPPAQ to identify “Active” individuals = 19% Specificity of GPPAQ to identify “Not active” individuals = 85% For GPPAQ-WALK: Categorical Achievement: GPPAQ Inactive = 43% GPPAQ Moderately inactive = 10 % GPPAQ Moderately active = 15% GPPAQ Active = 32% Sensitivity of GPPAQ to identify “Active” individuals = 39% Specificity of GPPAQ to identify “Not active” individuals = 70%			
Sedentary Behaviour						
International Physical Activity Questionnaire - Sedentary Behavior (IPAQ-SB) ⁵¹	199; 57% women; N.R.	Criterion	Accelerometers (CSA model 7164) at least 5 days on of which 1 weekend day, 1-minute intervals	Short Form $\rho = 0.34$	-	-

Australian Longitudinal Study on Women's Health – Sedentary Behavior Questions (ALSWH - SB Q) ⁵²	200; 57% women; N.R.	7-d behaviour log	Long Form $\rho = 0.33$	-	-
	157; 100% Female; N.R.		Agreement between tertiles of sitting and physical inactivity categories $\kappa_{ppa} = 0.014$	-	-
			Weekday:		-
			Transport $ICC = 0.38$ (95% CI: 0.24 to 0.51)	-	
			Occup $ICC = 0.69$ (95% CI: 0.59 to 0.76)	-	
			TV $ICC = 0.60$ (95% CI: 0.49 to 0.69)	-	
			Computer $r = 0.74$	+	
			Other leisure $ICC = 0.27$ (95% CI: 0.12 to 0.41)	-	
			Weekend day:		
			Transport $ICC = 0.13$ (95% CI: -0.03 to 0.28)	-	
			Occup $ICC = 0.21$ (95% CI: 0.05 to 0.35)	-	
			TV $r = 0.53$	-	
			Computer $r = 0.64$	-	
			Other leisure $ICC = 0.37$ (95% CI: 0.22 to 0.50)	-	
			Weekend day:		
96; 100% men; N.R.	7-d behaviour log	Weekend day:			
		Transport $ICC = 0.63$ (95% CI: 0.49 to 0.73)	-		
		Occup $ICC = 0.77$ (95% CI: 0.68 to 0.84)	+		
		TV $ICC = 0.53$ (95% CI: 0.37 to 0.66)	-		
		Computer $ICC = 0.55$ (95% CI: 0.40 to 0.68)	-		

				Other leisure $r = 0.21$	-	
				Weekend day:		
				Transport $ICC = 0.12$ (95% CI: 0.08 to 0.31)	-	
				Occup $ICC = 0.37$ (95% CI: 0.18 to 0.53)	-	
				TV $ICC = 0.32$ (95% CI: 0.13 to 0.49)	-	
				Computer $r = 0.61$	-	
				Other leisure $r = 0.19$	-	
Self-reported sitting and breaks from sitting in the workplace (SBSW) ⁵³	59; 54% female; 32.1 $\pm$ 9.9 yrs	Criterion	Accelerometer (Actigraph GT3X), on hip	Sitting $\rho = 0.39^{**}$ (95% CI: 0.15 to 0.68)	-	-
				breaks from sitting $\rho = 0.30^*$ (95% CI: 0.15 to 0.69)	-	
			Inclinometer (activPAL3) on thigh	Sitting $\rho = 0.24$ (95% CI: -1.0 to 0.47)	-	
				breaks from sitting $\rho = 0.39^{**}$ (95% CI: 0.25 to 0.74)	-	
Workplace Sitting Breaks Questionnaire (SITBRQ) ⁵⁴	143; 62.6 %women; ~18<60 yrs	Criterion	Accelerometer (Actigraph GT1M), 7 days on hip	Frequency of breaks $\rho = 0.24$ (95% CI: 0.07 to 0.40)	-	-
				Total duration of breaks = 0.05 (95% CI: -0.12 to 0.22)	-	
Sedentary Behavior Questionnaire (SBQ) ⁵⁵	654; 45.9% Women; N.R.	Criterion	Accelerometer (Actigraph, Model WAM 7164); on hip, <100 counts per min	Female: Accelerometer mins with counts < 100		-
		Convergent	IPAQ	TV $r = 0.12^*$	-	
				Computer games $r = 0.04$	-	

		Sit listen to music $r = 0.01$	-
		Sit talk on telephone $r = 0.04$	-
		Office/paperwork $r = 0.17^{**}$	-
		Reading $r = 0.01$	-
		Playing musical instrument $r = 0.26^{***}$	-
		Arts and crafts $r = 0.06$	-
		Sitting driving in car $r = -0.04$	-
		Weekday (hours/day) $r = 0.06$	-
		Weekend (hours/day) $r = 0.18^{**}$	-
		Total hours/week $r = 0.10^*$	-
Criterion	Accelerometer (Actigraph, Model WAM 7164); on hip, <100 counts per min	Female: Accelerometer total activity mins/day	-
		TV $r = -0.08$	-
		Computer games $r = -0.05$	-
		Sit listen to music $r = -0.10$	-
		Sit talk on telephone $r = -0.02$	-
		Office/paperwork $r = -0.04$	-
		Reading $r = 0.01$	-
		Playing musical instrument $r = -0.05$	-
		Arts and crafts $r = -.08$	-
		Sitting driving in car $r = 0.09$	-

Convergent	IPAQ	Weekday (hours/day) $r = -0.07$	-
		Weekend (hours/day) $r = -0.08$	-
		Total hours/week $r = -0.08$	-
		Female: IPAQ ST hours/day	-
		TV $r = 0.26^{***}$	-
		Computer games $r = 0.05$	-
		Sit listen to music $r = 0.02$	-
		Sit talk on telephone $r = 0.12^*$	-
		Office/paperwork $r = 0.33^{***}$	-
		Reading $r = 0.11^*$	-
		Playing musical instrument $r = -0.11$	-
		Arts and crafts $r = 0.07$	-
		Sitting driving in car $r = 0.07$	-
		Weekday (hours/day) $r = .21^{***}$	-
		Weekend (hours/day) $r = 0.36^{***}$	-
		Total hours/week $r = 0.28^{***}$	-
Criterion	Accelerometer (Actigraph, Model WAM 7164); on hip, <100 counts per min	Male: Accelerometer mins with counts < 100	-
		TV $r = -0.001$	-
		Computer games $r = 0.01$	-
		Sit listen to music $r = 0.01$	-

		Sit talk on telephone $r = -0.08$	-
		Office/paperwork $r = 0.003$	-
		Reading $r = 0.01$	-
		Playing musical instrument $r = 0.04$	-
		Arts and crafts $r = -0.04$	-
		Sitting driving in car $r = 0.03$	-
		Weekday (hours/day) $r = -0.02$	-
		Weekend (hours/day) $r = -0.005$	-
		Weekend (hours/day) $r = -0.005$	-
Criterion	Accelerometer (Actigraph, Model WAM 7164); on hip, <100 counts per min	Male: Accelerometer total activity mins/day	-
		TV $r = 0.02$	-
		Computer games $r = 0.003$	-
		Sit listen to music $r = -0.02$	-
		Sit talk on telephone $r = -0.01$	-
		Office/paperwork $r = -0.004$	-
		Reading $r = -0.06$	-
		Playing musical instrument $r = 0.02$	-
		Arts and crafts $r = -0.003$	-
		Sitting driving in car $r = -0.04$	-
		Weekday (hours/day) $r = -0.03$	-

				Weekend (hours/day) $r = -0.005$	-	
				Total hours/week $r = -0.03$	-	
				Male: IPAQ total ST - including transport hours/day		-
				TV $r = 0.20^{***}$	-	
				Computer games $r = 0.06$	-	
				Sit listen to music $r = 0.11^*$	-	
				Sit talk on telephone $r = 0.17^{***}$	-	
				Office/paperwork $r = 0.31^{***}$	-	
				Reading $r = 0.02$	-	
				Playing musical instrument $r = 0.00$	-	
				Arts and crafts $r = 0.04$	-	
				Sitting driving in car $= 0.19^{***}$	-	
				Weekday (hours/day) $r = 0.24^{***}$	-	
				Weekend (hours/day) $r = 0.38^{***}$	-	
				Total hours/week $r = 0.31^{***}$	-	
SED-GIH ⁵⁶	284; 66,20 % women; 42.9 ± 8.9 yrs	Criterion	Inclinometer (activPAL3 micro), on leg, 7 days	SED-GIH answer categories and continuous activPAL-SIT for all days $\rho = 0.31$ (95% CI= 0.20 to 0.41).	-	-
				Agreement between the SED-GIH answer categories and categorized activPAL-SIT weighted $Kappa = 0.12$ (95% CI = 0.05 to 0.18)	-	
				37.0% of the participants total estimated their sitting correctly, 40.8% underestimated their sitting and 22.2% overestimated their sitting.		

				The 7–9 and 10–12 h spent sitting groups presented the highest numbers of correct estimations with 47.1 and 64.3%, respectively. participants who chose the answer ≤ 3 h in the SED-GIH question all underestimated their sitting time as compared to the categorical values of activPAL-SIT. Furthermore, nearly all participants who chose ≥ 13 h overestimated their sitting time compared to activPAL-SIT.		
Workforce Sitting Questionnaire (WSQ) ⁵⁷	95; 63.2% women; 42.9 $\pm$ 8.9 yrs	Criterion	Accelerometer (Actigraph GT1M), on hip, activity counts were recorded in 10 seconds intervals and aggregated into 1 min epochs	At work, workday $r = 0.45$ Total, all domains, workday $r = 0.34^*$ Total, all domains, non-workday $r = 0.23^*$ Average total, work, and non-workday $r = 0.40^*$ Bland Altman in average total sitting time between the WSQ and accelerometers: Mean difference = 44.55 mins/day, $p < 0.05$; $LoA = -295.31$ to 384.41 min/day. Bland Altman in sitting time at work on a workday when the WSQ was compared with accelerometers: mean difference 1.58 min/workday; $p > 0.05$; $LoA = -227.86$ to 231.02 min/day	-	-
Japanese-Language Self-reported Measures for Assessing Adults Domain-	392; 60.2% women; 50.1 $\pm$ 7 yrs	Criterion	Accelerometer, (Active style Pro), 7 days, 1-min epoch	Workday $\rho = 0.57^{**}$	-	-

Specific Sedentary Time
(JSRM - SB)⁵⁸

				Non-Workday $\rho = 0.23^{**}$	-	
				Whole week $\rho = 0.49^{**}$	-	
				Bland Altman for whole week: Mean difference = -13.4 min/day; LoA = -1.96 SD: -361.9 to 1.96 SG: 335.2 min/day		
Longitudinal Aging Study Amsterdam questionnaire (LASA) ⁵⁹	83; 49.4% women; 64 - 92 yrs	Criterion	Accelerometer (Actigraph Model GT3X), on waist, 8 days	Total ST (10 items) $\rho = 0.35^*$	-	-
				Total ST (6 items) $\rho = 0.46^*$	-	
				Bland Altman = Total sedentary time: Mean difference = 2.1 hours, with LoA of -7.40 to 3.25 hours		
SB question of the Yale Physical Activity Survey (YPAS - SB) ⁶⁰	58; 79% female; 66 - 88 yr	Criterion	Accelerometer (Actigraph GT1M) on hip, 10 days, 1-minute epoch	Sitting time agreement YPAS and accelerometer = 8.6%		-
				Sitting time $k = -0.0003$ (-0.0025 to 0.0019), (P trend < 0.01)	-	
Community Health Activities Model Program for Seniors SB questions (CHAMPS - SB) ⁶⁰	58; 79% women; 66 - 88 yrs	Criterion	Accelerometer (Actigraph GT1M) on hip, 10 days, 1-minute epoch	Sitting time Lin's concordance correlation coefficient = 0.005 (-0.010 to 0.020)	-	-
				Sitting time $r = 0.14$; p-trend = 0.53	-	
				Bland Altman: SB mean difference 5.21 hours/day LoA = 2.2 to 8.3 lower than accelerometer-derived		
Cancer Prevention Study-3 Sedentary Time Survey (CPS-	713; 59% women; 31 -	Criterion	Accelerometer (Actigraph GT3x), on	Total ST $r = 0.41$ (95% CI: 0.35 to 0.47)	-	-

3 sitting time) ⁶¹	72 yrs		hip, 7 days			
Sleep						
BRFSS sleep questions (BRFSS Sleep) ⁶²	300; 68% women; 18 - 96 yrs	Criterion	Camtech Pro-Diary device with integrated activity monitor designed to collect patient reported outcome (subjective data) and actigraphy (objective data) simultaneously, 2 weeks, 1 minute epoch, on wrist	Bland Altman: the lack of agreement was 0.05 ± 1.2 (95% CI -2.1 to 2.2; considering the SD, 95% of people could report their total sleep time subjectively around 2 hours different from what would be measured objectively		
		Convergent	proposed question that the authors theorized: "How many hours of sleep do you need to feel rested?"	Bland Altman: the lack of agreement is -0.41 ± 1.6 (95% CI to 3.5 to 2.7). The lack of agreement is overall around 25 min, and 95% of the population may report a sleep opportunity deficit of as much as 3.5 hours.		
Physical Activity + Sedentary Behaviour						
Kaiser Physical Activity Survey (KPAS) ⁶³	50; 100% women; 20-60 yrs	Criterion	Accelerometer (Caltrac), on Hip, 7 days	Caregiving score $\rho = 0.17$	-	-
				Housework score $\rho = -0.03$	-	
				Housework/caregiving score $\rho = -0.01$	-	
				Sports/exercise $\rho = 0.57^{**}$	-	
				Active living habits $\rho = 0.34^*$	-	
				Occupation $\rho = 0.16$	-	
				3-point summary $\rho = 0.53^{**}$	-	

		Physical activity record	4-point summary $\rho = 0.49^{**}$	-	
			Caregiving score $\rho = 0.56^{**}$	-	-
			Housework score $\rho = -0.64^{**}$	-	
			Housework/caregiving score $\rho = 0.67^{**}$	-	
			Sports/exercise $\rho = 0.73^{**}$	+	
			Active living habits $\rho = 0.22$	-	
			Occupation $\rho = 0.35^*$	-	
			3-point summary $\rho = 0.42^{**}$	-	
			4-point summary $\rho = 0.35^*$	-	
Sedentary, Transportation and Activity Questionnaire (STAQ) ⁶⁴	96; 53.1% women; 40.5 $\pm$ 14.3 yrs	Accelerometer (Actigraph GT3X), on hip, 7 days, 100 counts per minutes	Sitting Time:		-
			Total ICC = 0.44 (95% CI: 0.25 - 0.60)	-	
			Bland-Altman: With an important underestimation (-17 h/week) and wide LoA (-43.8 to 34.6 h/week)		
			Work ICC = 0.82 (95% CI: 0.73 to 0.88)	+	
			Transport ICC = 0.53 (95% CI: 0.35 to 0.67)	-	
			Leisure time ICC = 0.33 (95% CI: 0.12 to 0.51)	-	
			Specific sedentary behaviours:		
			Total ICC = 0.18 (95% CI: -0.04 to 0.38)	-	
			TV/DVD ICC = 0.34 (95% CI: 0.14 to 0.52)	-	
			Computer/tablet/video games ICC = 0.45 (95%	-	

				CI: 0.26 to 0.60)		
International Physical Activity Questionnaire (IPAQ) ⁶⁵	26-151; N.R.; 18 - 65 yrs	Criterion	Accelerometer (CSA model 7164), 7 days, 1-min interval	Contextualized logbook	Active transport:	-
				Walking <i>ICC</i> = 0.38 (95% CI: 0.19 to 0.54)	-	
				Walking + cycling <i>ICC</i> = 0.38 (95% CI: 0.18 to 0.54)	-	
				Passive transport:		
				All transportation type <i>ICC</i> = 0.40 (95% CI: 0.21 to 0.56)	-	
				Car <i>ICC</i> = 0.66 (95% CI: 0.52 to 0.76)	-	
	26-127; N.R.; 18 - 65 yrs	Criterion	Accelerometer (CSA model 7164), 7 days, 1-min interval	Short form past week:		-
				Physical activity Total <i>rho</i> = From 0.02 to 0.47, depending on the country	-	
				ST <i>rho</i> = 0.12 - 0.49, depending on the country	-	
				Guideline's compliance ACC = 0.46 to 0.93, depending on the country	+	
				Short form usual week:	-	
				Physical activity total <i>rho</i> =- 0.12 to 0.32, depending on the country	-	
	26 - 151; N.R.; 18-65 yrs	Criterion	Accelerometer (CSA model 7164), 7 days, 1-min interval	ST <i>rho</i> = 0.07 to 0.26, depending on the country	-	
Guideline's compliance ACC= 0.50 to 0.75, depending on the country				+		
Long form past week:				-		

			Physical activity total $\rho = 0.05$ to 0.52 , depending on the country	-	
			ST $\rho = 0.25$ to 0.51 , depending on the country	-	
			Guideline's compliance ACC = 0.31 to 1.0 , depending on the country	+	
			Long form usual week:		-
26 – 127; N.R.; 18-65	Criterion	Accelerometer (CSA model 7164), 7 days, 1-min interval	Physical activity total $\rho = -0.27$ to 0.36 , depending on the country	-	
			Sitting $\rho = 0.14$ to 0.22 , depending on the country	-	
			Guideline's compliance ACC = 0.35 to 0.72 , depending on the country	+	
26 – 151; N.R.; 18-65 yrs	Convergent	Long form past week:	Short form past week		+
			Total physical activity $\rho = 0.78$ to 0.85 , depending on the country	+	
			ST $\rho = 0.89$ to 0.91 , depending on the country	+	
			Guideline's compliance ACC = 0.93 to 0.97 , depending on the country	+	
26 - 127; N.R.; 18-65 yrs	Convergent	Long form usual week	Short form usual week		+
			Total physical activity $\rho = 0.49$ to 0.78 , depending on the country	+	
			Sitting $\rho = 0.60$ to 0.96 , depending on the country	+	
			Guideline's compliance ACC = 0.83 to 0.91 , depending on the country	+	

Australian Women's Activity Survey (AWAS) ⁶⁶	75; 100% women; 32 ± 5 yrs	Criterion	Accelerometer (Actigraph) on waist, 7 days	Sitting Time $r = 0.32^*$	-	-
				LPA $r = 0.12$	-	
				MPA $r = 0.11$	-	
				VPA $r = 0.07$	-	
				Total Activity $r = 0.13$	-	
Workers' sitting- and walking-time questionnaire Time Method (WSWQ- t-method) ⁶⁷	64; 40% women; men mean age: 46.3 ± 8.0 yrs; women mean age: 35.8 ± 7.5 yrs	Criterion	Accelerometer (ActivPAL), on Leg, 7 days, 15 seconds intervals	Workday:		
				During working time:		-
				Sitting $\rho = 0.52^*$	-	
				Walking/Standing $\rho = 0.56^*$	-	
				Sitting $\kappa = 0.39^*$	-	
				Walking/Standing $\kappa = 0.38^*$	-	
				During non-working time:		
				Sitting $\rho = 0.55^*$	-	
				Walking/Standing $\rho = 0.58^*$	-	
				Sitting $\kappa = 0.43^*$	-	
				Walking/Standing $\kappa = 0.35^*$	-	
				Non-workday:		

The Physical Activity Scale for the Elderly (PASE) ⁶⁸	222; N.R.; N.R.	Convergent	Perceived health	Sitting $\rho = 0.25$	-	
				Walking/Standing $\rho = 0.30^*$	-	
				Sitting $\kappa = 0.13$	-	
				Walking/Standing $\kappa = 0.16^*$	-	
				Bland Altman: mean differences at work = -6.7 mins/day (P = 0.68); Mean differences at non workday = -114.7 mins/day (P < 0.01); At work LoA = -254 to 241 mins/day; Non workday LoA = -588 to 358 mins/day		
				PASE activity score $r = -0.25^{**}$	-	-
				Sick Impact Profile	PASE activity score $r = -0.42^{**}$	-
				Grip Strength	PASE activity score $r = 0.37^{**}$	-
				Balance	PASE activity score $r = 0.33^{**}$	-
				Accelerometer (Actigraph model 7164 and 71256) Waist, 7 days, epoch 1 minute	Sedentary duration $\rho = 0.12^{**}$	-
Community Health Activities Model Program for Seniors physical activity self-report questionnaire + transport items (CHAMPS+transport) ⁶⁹	870; 50.7% women; over 80 yrs	Criterion		Low-LPA duration $\rho = 0.06$	-	
				High-LPA duration $\rho = 0.27^{**}$	-	
				MVPA duration $\rho = 0.37^{**}$	-	
				Total physical activity duration $\rho = 0.38^{**}$	-	
				MVPA caloric expenditure/ wk $\rho = 0.38^{**}$	-	
				Total physical activity caloric expenditure/ wk $\rho = 0.39^{**}$	-	

				Bland Altman: The CHAMPS indicated fewer minutes/week of sedentary (Mean difference = -2841.6 min/wk; 95% CI = -4476.7 to -1206.5 min/wk) and low-light activity (Mean difference = -472.7 min/wk; 95th CI = -1937.2 to 991.9 min/wk) and more minutes of high-light (Mean difference = 395.5 min/wk; 95% CI = -346.2 to 1137.2 min/wk), moderate-to-vigorous (Mean difference = 222.4 min/wk; 95% CI = -402.9 to 847.5 min/wk), and total activity (Mean difference = 617.8 min/wk; 95% CI = -504.1 to 1739.7min/wk) activity relative to accelerometry.
Community Healthy Activities Model Program for Seniors (CHAMPS) ⁷⁰	249; 63.9% women; 65 -90 yrs	Known-groups validity	Comparison of those initially inactive,a somewhat active,b and active	Caloric expenditure per week in at least moderate intensity physical activities F-test = F2,246 = 5 20.85**
				Frequency per week in at least moderate intensity physical activities F-test = F2,246 = 38.93**
				Caloric expenditure per week in all listed physical activities F-test = F2,246 = 17.80**
				Frequency per week in all listed physical activities F-test = F2,246 = 29.26**
		Convergent	6-Min Walk	Caloric expenditure per week in at least moderate intensity physical activities $r = 0.27^{**}$
				Frequency per week in at least moderate intensity physical activities $r = 0.21^{**}$
				Caloric expenditure per week in all listed physical activities $r = 0.22^{**}$
				Frequency per week in all listed physical activities $r = 0.10$

			Self-Reported Physical Functioning	Caloric expenditure per week in at least moderate intensity physical activities $r = 0.30^{**}$	-	-
				Frequency per week in at least moderate intensity physical activities $r = 0.30^{**}$	-	
				Caloric expenditure per week in all listed physical activities $r = 0.27^{**}$	-	
				Frequency per week in all listed physical activities $r = 0.23^{**}$	-	
Modified Version of the MONICA Optional Study on Physical Activity Questionnaire (Modified MOSPA-Q) ⁷¹	70; N.R.; N.R.	Criterion		Walking $\rho = 0.27^{**}$	-	-
				Lifting/Carrying NA (low prevalence)	-	
				Standing $\rho = 0.49^*$	-	
				Sitting $\rho = 0.52^*$	-	
Occupational Sitting and Physical Activity Questionnaire (OSPAQ) ^{71,72}	76; N.R.; N.R.	Criterion	Accelerometer (ActiGraph GT1M), on Hip, 7 days, 10 seconds intervals and aggregated into 1-min epochs	Walking $\rho = 0.29^{**}$	-	-
				Heavy Work NA (low prevalence)	-	
				Standing $\rho = 0.49^*$	-	
				Sitting $\rho = 0.65^*$	-	
				Bland-Altman: participants overestimated their occupational sitting time at high values and underestimated their occupational sitting at low values on the OSPAQ VS accelerometers. Differences were generally small (250- to 450-min). The mean difference		

				between OSPAQ sitting time and accelerometer sedentary time at work = 22 min, 95% CI = 3 to 41 min).		
	127; 82.7% women; 44.11 ± 11.16 yrs	Convergent	IPAQ	Walking $\rho = 0.43^*$ (LoA -16.05 to 17.05%; Bland-Altman bias 0.50 % (SD8.44 %))	-	-
				Heavy Work N.R.	-	
				Standing $\rho = 0.56^*$ (LoA -15.94 to 10.19%; Bland-Altman bias 2.87% (SD6.66 %))	-	
				Sitting $\rho = 0.62^*$ (LoA -20.37 to 25.16%; Bland-Altman bias 2.39 % (SD11.61%))	-	
Rapid Assessment Disuse Index (RADI) ⁷³	151; N.R.; N.R.	Criterion	Accelerometer (ActiGraph GT3X), on hip, 7 days, 60 min epoch	Cumulative RADI score:		-
				ST $\rho = 0.402^{***}$	-	
				Sedentary breaks $\rho = -0.425^{**}$	-	
				LPA $\rho = -0.406^{**}$	-	
				MVPA $\rho = -0.063$		
				Distinction between high sedentary and low sedentary individuals: AUC = 0.72	+	
				RADI score of 27 resulted in a sensitivity of 0.60 and specificity of 0.74; a score of 26 resulted in sensitivity 0.79 and specificity 0.63, and when the RADI score was 25, the sensitivity remained constant (0.79) and specificity decreased (0.59).	-	
Global Physical Activity Questionnaire (GPAQ) ⁷⁴	148; N.R.; N.R.	Convergent	IPAQ	Total vigorous $\rho = 0.68^{**}$	-	-
				Total moderate $\rho = 0.68^{**}$	-	

				Total physical activity $\rho = 0.29^{**}$	-	
				Sedentary time $\rho = 0.68^{**}$	-	
				inactive $\kappa = 0.52$ (89.2%)	-	
	Criterion	Pedometer		Total physical activity time $\rho = 0.23^{**}$	-	-
				Total sedentary time $\rho = 0.00$	-	
Sedentary Behaviour + Sleep						
SIT-Q ⁷⁵	69; N.R.; N.R.	Convergent	Seven-Day Activity Diary	Meals $\rho = 0.29^*$	-	-
				Transport $\rho = 0.34^{**}$	-	
				Occup $\rho = 0.75^{**}$	+	
				Child and elder care $\rho = 0.46^{**}$	-	
				Leisure Time $\rho = 0.26^*$	-	
				Total sitting time $\rho = 0.52^{**}$	-	
Physical Activity + Sedentary Behaviour + Sleep						
Physical Activity Questionnaire (PAQ)(Norman et al., 2001)	111 men; N.R.	Convergent	Self-administered structured 7-day physical activity diary	Crude Total physical activity $\rho = 0.22^*$	-	-
				Total activity score $\rho = 0.53^*$	-	
				work/occupation $\rho = 0.38^*$	-	
				home/household $\rho = 0.58^*$	-	
				activity leisure-time $\rho = 0.37^*$	-	
				inactive leisure (TV/reading) $\rho = 0.49^*$	-	
				sleep $\rho = 0.57^*$	-	

Athens Physical Activity Questionnaire (APAQ) ⁷⁷	79; 53% Women; 28 ± 6 year	Criterion	Accelerometer (RT3 Tri-axial Research Tracker)	Total energy expenditure $\rho = 0.84$ (0.44 and 0.63 for both genders, women and men, respectively (all $P < 0.01$)). Bland-Altman plotting showed a good agreement between APAQ and RT3 - differences within the 95% <i>LoA</i> . Furthermore, the lack of significant slope ($r < 0.14$, $P > 0.385$) indicated no proportional bias in energy expenditure derived from the APAQ.	+	+
Sedentary Time and Activity Reporting Questionnaire (STAR-Q) ⁷⁸	99; N.R.; N.R.	Convergent	7-day activity diary	Total energy expenditure, kcal/day $\rho = 0.74^{**}$ AEE, kcal/day $\rho = 0.61^{**}$ AEE, kcal/kg.day $\rho = 0.45^{**}$ Sleeping $\rho = 0.62^{**}$ Stair-climbing, flights/day $\rho = 0.41^{**}$ Active sitting $\rho = 0.30^*$ Overall Activity: SB $\rho = 0.40^{**}$ Light intensity $\rho = 0.29$ Mod intensity $\rho = 0.57^{**}$ Vig intensity $\rho = 0.68^{**}$ Exercise, sports, and leisure activity General = 0.47^{**} Light intensity $\rho = 0.21^*$	+	-

			Mod intensity $\rho = 0.35^{**}$	-	
			Vig intensity $\rho = 0.49^{**}$	-	
			Occup activity:		
			General $\rho = 0.71^{**}$	+	
			Sitting $\rho = 0.75^{**}$	+	
			SB $\rho = 0.76^{**}$	+	
			Light intensity $\rho = 0.24^*$	-	
			Mod intensity $\rho = 0.30^*$	-	
Question 8 of the Paffenbarger Physical Activity Questionnaire (Q 8 PPAQ) ⁷⁹	419; 50.8% women; men age: 43.8 ± 15.8 yrs; Women age: 44.3 ± 16.5 yrs	Criterion	Accelerometer, on hip, 25-second epochs, 4 consecutive days 2 days during the week and 2 days over the weekend	Light intensity $\rho = 0.02$ (95% CI: -0.09 - 0.11)	- -
				Moderate intensity $\rho = 0.15^{**}$ (95% CI: 0.11 to 0.30)	-
				Vigorous intensity $\rho = 0.20^{**}$ (95% CI: -0.01 to 0.19)	-
				Sedentary Time $\rho = 0.20^{**}$ (95% CI: 0.14 to 0.33)	-
				METs light intensity = 0.26 (95% CI: 0.20 to 0.40)	-
				METs moderate intensity = 0.17 ^{**} (95% CI: 0.13 - 0.33)	-
				METs vigorous intensity = -0.01 (95% CI: -0.13 to 0.07)	-
				METs SB = -.24 ^{**} (95% CI: -0.39 to 0.20)	-

EPIC-Norfolk Physical Activity Questionnaire (EPAQ2) ⁸⁰	173; 51.45% women; men age 58.8 ± 7.9 yrs; women age 55.4 ± 6.7 yrs	Criterion	Heart rate monitoring (kJ/h)	TV $\rho = -0.7$	-	-
				Activity at home $\rho = -0.04$	-	
				Activity at work $\rho = 0.17^*$	-	
				Recreational activity $\rho = 0.13$	-	
				VPA $\rho = 0.01$	-	
				Physical activity index $\rho = 0.28^{**}$	-	
		Convergent	VO2max	TV $\rho = -0.19^*$	-	-
				Activity at home $\rho = -0.09$	-	
				Activity at work $\rho = 0.01$	-	
				Recreational activity $\rho = 0.16^*$	-	
				VPA $\rho = 0.16^*$	-	
				Physical activity index $\rho = 0.15^*$	-	
Workers' sitting- and walking-time questionnaire Percentage Method (WSWQ - p-method) ⁶⁷	64; 40% female; men age: 46.3 ± 8.0 yrs; women age: 35.8 ± 7.5 yrs	Criterion	Accelerometer (ActivPAL), on Leg, 7-days, 15-s intervals	Workday:		-
				During working time:		
				Sitting $\rho = 0.59^*$	-	
				Walking/Standing $\rho = 0.56^*$	-	

New Questionnaire on Physical Activity (NQPA) ⁸¹	111; 46.85% women; <50yrs = 56.76%; >=50 yrs = 43.24%	Convergent	Physical activity Diary	Sitting K = 0.44*	-
				Walking/Standing k = 0.35*	-
				During non-working time:	
				Sitting ρ = 0.57*	-
				Walking/Standing ρ = 0.61*	-
				Sitting K = 0.36*	-
				Walking/Standing k = 0.40*	-
				Non-workday:	
				Sitting ρ = 0.42*	-
				Walking/Standing ρ = 0.45*	-
				Sitting K = 0.23*	-
				Walking/Standing k = 0.21*	-
				Bland Altman: mean differences = 34.5 min/day (P = 0.03); Mean differences at non workday = -55.7 min/day (P = 0.02); At work LoA = -200 - 269 min/day; Non workday LoA = -392 - 281 min/day	
				Men:	-
				1st questionnaire r = 0.66 (95% CI: 0.49 to 0.78)	-
				Women:	
				1st questionnaire r = 0.43 (0.18–0.63)	-

				Bland-Altman: The limits of 2 standard deviations below and above the mean difference were -3368 and 3243 kJ. This means that for 95% of the subjects the outcome of the second questionnaire fell within an interval of 3368 kJ below and 3243 kJ above the outcome of the first.		
Web-Based Physical Activity Questionnaire (Active-Q) ⁸²	148 Men; 33 - 86 yrs	Criterion	Accelerometer (GENEA), on wrist, 6 days, 1-minute epoch	SB $r = 0.19$ (95% CI: 0.04 to 0.34)	-	-
				LPA $r = 0.15$ (95% CI: 0.00 to 0.31)	-	
				SB+LPA = 0.35 (95% CI: 0.19 to 0.51)	-	
				MPA $r = 0.27$ (95% CI: 0.12 to 0.42)	-	
				VPA $r = 0.54$ (95% CI: 0.42 to 0.67)	-	
				MVPA $r = 0.35$ (95% CI: 0.21 to 0.48)	-	
				Bland Altman: SB: mean difference = -178, 95%; LoA= -606 – 250 mins/day		
				Bland Altman: LPA: mean difference=-178, 95% LoA=-606 to 250 mins/day		
				Bland Altman: SB+LPA: mean difference=-329, 95% LoA=-329 to 146 mins/day		
				Bland Altman: MPA: mean difference=76, 95% LoA=-157 to 309 mins/day		
Flemish Physical Activity Computerized Questionnaire (FPACQ) ⁸³	62; 32 men: 39.28 ± 11.72 yrs; 30	Criterion	Accelerometer (RT3 Triaxial Research Tracker, StayHealthy,	Bland Altman: VPA: mean difference=15, 95% LoA=-33 to 64 mins/day		
				Bland Altman: MVPA: mean difference=91, 95% LoA=-147 to 329 mins/day		
				Employed/Unemployed Men	-	-

women: 39.13 ± 11.96 yrs	Inc., Monrovia, CA), on hip, all 1-min epochs over 7 days		
		Time/week spent on sports participation $r = 0.77^{***}$	+
		Energy expenditure/week on sports participation $r = 0.47^{**}$	-
		Average energy expenditure on sports participation $r = 0.54^{**}$	-
		Time/week spent eating $r = 0.53^{**}$	-
		Time/week spent sleeping $r = 0.69^{***}$	-
		Time/week spent watching television or videos or playing computer games $r = 0.69^{***}$	-
		Time/week spent on leisure-time active transportation $r = 0.55^{**}$	
		Time/week spent on active leisure-time activities $r = 0.35$	-
		Energy expenditure/week on active leisure time-activities $r = 0.37^*$	-
		Average energy expenditure on active leisure-time activities $r = 0.51^{**}$	-
		Time/week spent on occupation and transportation to and from occupation $r = 0.78^{***}$	+
		Energy expenditure/week on occupation and transportation to and from occupation $r = 0.85^{***}$	+
		Average energy expenditure on occupation and transportation to and from occupation $r = 0.84^{***}$	+
		Overall energy expenditure during a usual week $r = 0.80^{***}$	+

Physical activity level (MET) $r = 0.56^{**}$	-
Employed/Unemployed Women	
Time/week spent on sports participation $r = 0.63^{***}$	-
Energy expenditure/week on sports participation $r = 0.67^{***}$	-
Average energy expenditure on sports participation $r = 0.27$	-
Time/week spent eating $r = 0.56^{**}$	-
Time/week spent sleeping $r = 0.60^{***}$	-
Time/week spent watching television or videos or playing computer games $r = 0.83^{***}$	+
Time/week spent on leisure-time active transportation $r = 0.49^{**}$	-
Time/week spent on active leisure-time activities $r = 0.75^{***}$	+
Energy expenditure/week on active leisure time-activities $r = 0.67^{***}$	-
Average energy expenditure on active leisure-time activities $r = 0.84^{***}$	+
Time/week spent on occupation and transportation to and from occupation $r = 0.88^{***}$	+
Energy expenditure/week on occupation and transportation to and from occupation $r = 0.83^{***}$	+
Average energy expenditure on occupation and transportation to and from occupation $r = 0.78^{***}$	+

49; 30 men:
64.47 ± 5.48
yrs; 19
women: 65.37
± 4.98 yrs

Overall energy expenditure during a usual week $r = 0.65^{***}$	-
Physical activity level (MET) $r = 0.44^*$	-
Retired Men	
Time/week spent on sports participation $r = 0.66^{***}$	-
Energy expenditure/week on sports participation $r = 0.37$	-
Average energy expenditure on sports participation $r = 0.25$	-
Time/week spent eating $r = 0.33$	-
Time/week spent sleeping $r = 0.57^{**}$	-
Time/week spent watching television or videos or playing computer games $r = 0.78^{***}$	+
Time/week spent on leisure-time active transportation $r = 0.55^{**}$	-
Time/week spent on active leisure-time activities $r = 0.33$	-
Energy expenditure/week on active leisure time-activities $r = 0.39^*$	-
Average energy expenditure on occupation and transportation to and from occupation $r = 0.41^*$	-
Overall energy expenditure during a usual week $r = 0.55^{**}$	-
Physical activity level (MET) $r = 0.39^*$	-
Retired Women	

Time/week spent on sports participation $r = 0.38$	-
Energy expenditure/week on sports participation $r = 0.51^*$	-
Average energy expenditure on sports participation $r = 0.23$	-
Time/week spent eating $r = 0.15$	-
Time/week spent sleeping $r = 0.51^*$	-
Time/week spent watching television or videos or playing computer games $r = 0.80^{***}$	+
Time/week spent on leisure-time active transportation $r = 0.52^*$	-
Time/week spent on active leisure-time activities $r = 0.28$	-
Energy expenditure/week on active leisure time-activities $r = 0.44$	-
Average energy expenditure on occupation and transportation to and from occupation $r = 0.64^{**}$	-
Overall energy expenditure during a usual week $r = 0.85^{***}$	+
Physical activity level (MET) $r = 0.50^*$	-

Abbreviations: n = Sample Number; SD = Standard Deviation; yrs= years; CI =Confidence interval; VPA = Vigorous Physical Activity; MPA = Moderate Physical Activity; $MVPA$ = Moderate-Vigorous Physical Activity; MET = Metabolic Equivalent Task; ACC = average correct classification; * $p \leq 0.05$; ** $p \leq 0.001$; *** $p \leq 0.0001$; + = Adequate; - = Inadequate;

References

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4.2.5. Supplementary work 5 - Reliability

Table S3. Reliability Results

Questionnaire	Sample		Reliability		
	n; % Women; Age mean $\pm$ SD or Age range (years)	Time between test and retest	Results	Quality of reliability results	Overall Quality
Physical Activity					
Nord-Trøndelag Health Study PA Questionnaire (HUNT 1) ³⁰	102; N.R.; N.R.	1 week	Frequency $\rho = 0.87^{**}$	+	+
			Intensity: $\rho = 0.87^{**}$	+	
			Duration: $\rho = 0.78^{**}$	-	
			Frequency Weighted $\kappa = 0.80$	+	
			Intensity Weighted $\kappa = 0.82$	+	
			Duration Weighted $\kappa = 0.69$	-	
Past Year Total Physical Activity Questionnaire (PYTPAQ) ³¹	154; 51% women; 48.7 $\pm$ 7.7	9 weeks	Total physical activity $ICC = 0.66$ (95% CI: 0.56 to 0.74)	-	-
			VPA $ICC = 0.72$ (95% CI: 0.56 to 0.83)	+	

			LPA /MPA ICC = 0.55 (95% CI: 0.40 to 0.67)	-	
			Occup ICC = 0.58 (95% CI: 0.47 to 0.68)	-	
Physical Activity Assessment Tool (PAAT) ³²	68; N.R.; N.R.	1 week	Total physical activity $r = 0.62^{***}$	-	-
			MPA $r = 0.49^{***}$	-	
			VPA $r = 0.77^{***}$	+	
Minnesota Leisure Time Physical Activity Questionnaire (Minnesota LTPA Q) ³³	78; 64.1% women; 20-59 years	1 month	Total $r = 0.92$	+	+
			LPA $r = 0.73$	-	
			MPA $r = 0.80$	+	
			Vig $r = 0.95$	+	
			Household chores $r = 0.88$	+	
Single Item Physical Activity Measure (SI PA M) ³⁴	240; 50% women; 18-64 years	2 to 5 days	Physical activity wk $r = 0.72$	-	-
			Physical activity month $r = 0.86$	+	
			Agreement categorical variables: Weighted $kappa = 0.82$ (95% CI: 0.69 to 0.82)	+	

Godin Questionnaire (Godin Q) ³³	77; N.R.; N.R.	1 month	Leisure score $r = 0.62$	-	-
			LPA $r = 0.24$	-	
			MPA $r = 0.36$	-	
			VPA $r = 0.84$	-	
CARDIA Physical Activity History (CARDIA) ³³	78; 64.1% women; 20-59 years	1 month	Total physical activity $r = 0.88$	+	+
			MPA $r = 0.66$	-	
			Vig $r = 0.91$	+	
College Alumnus Questionnaire (College Alumnus Q) ³³	58; N.R.; N.R.	1 month	Total index $r = 0.72$	-	-
			Stairs $r = -0.78$	-	
			Blocks $r = 0.63$	-	
			Sports $r = 0.75$	-	
Minnesota Heart Health Program Questionnaire (MHHP Q) ³³	77; N.R.; N.R.	1 month	Work index $r = 0.91$	+	+
			Leisure index $r = 0.86$	+	

Modified Historical Leisure Activity Questionnaire (MHLAQ) ³⁵	131; N.R.; 50.4 ± 7.6 years	1 yr	Total physical activity <i>ICC</i> = 0.82**	+	+
			MPA <i>ICC</i> = 0.79	+	
			VPA <i>ICC</i> = 0.86	+	
			Leisure physical activity <i>ICC</i> = 0.80	+	
			Household physical activity <i>ICC</i> = 0.73	+	
Modified version Active Australia Survey 1(MV – AAS1) ³⁶	159 women; 54-59 years	Median: 13 days	No physical activity category % agreement = 61%	?	?
			Low PA category % agreement = 56%		
			MPA category % agreement = 40%		
			High physical activity category % agreement = 65%		
			Meet guidelines category % agreement = 76%		
			Frequency walking <i>rho</i> = 0.58	-	-
			Frequency MPA <i>rho</i> = 0.56	-	
			Frequency VPA <i>rho</i> = 0.60	-	

			Frequency Total physical activity $\rho = 0.58$	-	
			Mins/week walking $\rho = 0.58$	-	
			Mins/week MPA $\rho = 0.56$	-	
			Mins/week VPA $\rho = 0.61$	-	
			Mins/week Total physical activity $\rho = 0.64$	-	
Modified version Active Australia Survey (MV – AAS2) ³⁷	63; 63% women; 49.5 ± 12.5 years	N.R.	Mins/week MPA $\rho = 0.40$ (95% CI: 0.16 to 0.59)	-	-
			Mins/week VPA $\rho = 0.64$ (95% CI: 0.47 to 0.77)	-	
			Mins/week MVPA $\rho = 0.80$ (95% CI: 0.68 to 0.87)	+	
			Mins/week walking $\rho = 0.76$ (95% CI: 0.63 to 0.85)	-	
			Days/week MPA $\kappa = 0.63$ (95% CI: 0.36 to 0.76)	-	
			Days/week VPA $\kappa = 0.43$ (95% CI: 0.34 to 0.73)	-	
			Days/week MVPA $\kappa = 0.83$ (95% CI: 0.61 to 0.93)	+	
			Days/week walking $\kappa = 0.64$ (95% CI: 0.45 to 0.81)	-	

			Measurement error: Bland-Altman: LoA = - 8.46 ± 110.96 + 0.54 x average of AAS administrations.	?	?
Adapted from Active Australia Survey (Adapt AAS) ³⁸	118; 53% women; 38 ± 15 years	3 days	Mins/week men MPA ICC = 0.45 (95% CI: 0.21 to 0.64)	-	-
			Mins/week men VPA ICC = 0.85 (95% CI: 0.74 to 0.91)	+	
			Mins/week men walk ICC = 0.22 (95% CI: - 0.05 to 0.46)	-	
			Mins/week men Total physical activity ICC = 0.65 (95% CI: 0.33 to 0.84)	-	
			Days/week men MPA ICC = 0.71 (95% CI: 0.54 to 0.82)	+	
			Days/week men VPA ICC = 0.38 (95% CI: 0.13 to 0.59)	-	
			Days/week men walking ICC = 0.67 (95% CI: 0.48 to 0.78)	-	
			Mins/week women MPA ICC = 0.52 (95% CI: 0.32 to 0.68)	-	
			Mins/week women VPA ICC = 0.65 (95% CI: 0.48 to 0.77)	-	
			Mins/week women walk ICC = 0.75 (95% CI: 0.62 to 0.84)	+	
			Mins/week women Total physical activity ICC = 0.80 (95% CI: 0.69 to 0.87)	+	
			Days/week women MPA ICC = 0.53 (95% CI: 0.33 to 0.68)	-	

				Days/week women VPA $ICC = 0.89$ (95% CI: 0.82 to 0.93)	+	
				Days/week women walking $ICC = 0.86$ (95% CI: 0.77 to 0.91)	+	
				Meet guidelines men $kappa = 0.64^{***}$ (agreement = 94.1%)	-	
				Meet guidelines women $kappa = 0.55^{***}$ (agreement = 95.2%)	-	
International Physical Activity Questionnaire – Walking Section (IPAQ-WS) ³⁹	1766; 55% women; 23-57 years	3 days		IPAQ S7S $\rho = 0.77$	-	-
				IPAQ SUS $\rho = 0.91$	+	
Short Questionnaire to Assess Health-enhancing physical activity (SQUASH) ⁴⁰	50; 28% women; 44 ± 6 years	2 weeks		Total activity score $\rho = 0.58$	-	-
				Within the intensity categories (2 to <4 MET) $\rho = 0.58$	-	
				Within the intensity categories (4 to <6.5 MET) $\rho = 0.54$	-	
				Within the intensity categories (>+ 6.5 MET) $\rho = 0.92$	+	
European Prospective Investigation into Cancer and Nutrition Physical Activity Questionnaire (EPIC PAQ) ⁴¹	182; 45% women; 50-65 years	10 months		Total non-occup physical activity $\rho = 0.65^{***}$ (95% CI: 0.55 to 0.72)	-	-
				VPA (self-rated) $\rho = 0.63^{***}$ (95% CI: 0.54 to 0.72)	-	

13-Item Physical Activity Questionnaire (13I-PAQ) ⁴²	54; N.R.; N.R.	2 to 3 weeks	VPA (MET-assigned) $\rho = 0.71^{***}$ (95% CI: 0.63 to 0.78)	-	
			LPA to MPA $\rho = 0.67^{***}$ (95% CI: 0.58 to 0.74)	-	
			Household physical activity $\rho = 0.73^{***}$ (95% CI: 0.66 to 0.79)	-	
			Recreational physical activity $\rho = 0.58^{***}$ (95% CI: 0.48 to 0.67)	-	
			Total physical activity index weighted $\kappa = 0.62^{***}$ (95% CI: 0.53 to 0.71)	-	
			Cambridge physical activity index weighted $\kappa = 0.66^{***}$ (95% CI: 0.58 to 0.74)	-	
			Measurement error: Although the mean difference in MET-hours/week of non-occupational activity was small, a Bland-Altman plot of these data (not presented) showed wide 95% LoA (-116.2 to 115.0).	?	?
			Women		+
			Total physical activity $ICC = 0.74$	+	
			Sport $ICC = 0.83$	+	
			LTPA $ICC = 0.81$	+	

				OHPA <i>ICC</i> = 0.63	-	
				Men		
				Total physical activity <i>ICC</i> = 0.78	+	
				Sport <i>ICC</i> = 0.92	+	
				LTPA <i>ICC</i> = 0.79	+	
				OHPA <i>ICC</i> = 0.59	-	
Questionnaire d'Activité Physique pour les Personnes Âgées (QAPPA) ⁴³	225; 62.7% women; 69.5 ± 7.3 years	1 year		Moderate (METM) = <i>ICC</i> = 0.46	-	-
				Vigorous (METV) <i>ICC</i> = 0.63	-	
				Moderate-to-vigorous (METT) <i>ICC</i> = 0.64	-	
				"'physically active vs inactive' = 79.6% of individuals received the same classification at both test and retest (<i>kappa</i> = 0.44)	-	
				Measurement error: Bland Altman: There was no sizeable trend, but some variability was observed in both directions.	?	?
Incidental and Planned Exercise Questionnaire (IPEQ) ⁴⁴	"Past Week Version" = 30	1 week		"Past Week Version" <i>ICC</i> = 0.77	+	+

	"Past 3 months Version" = 50		"Past 3 months Version" ICC = 0.84	+	
Physical Activity Questionnaire for Elderly Japanese (PAQ-EJ) ⁴⁵	147; 58.50% women; 65-85 years	1 month	Total Score $r = 0.70$	-	-
			Subtotal of lower intensity activity categories $r = 0.64$	-	
			Subtotal of higher intensity activity categories $r = 0.71$	-	
The Longitudinal Ageing Study Amsterdam Physical Activity Questionnaire (LAPAQ) ⁴⁶	86; 52% women; 65.4–87.6 years	2 weeks	Total physical activity $r = 0.68$ (95% CI: 0.55 to 0.80)	-	-
			≥ 6 METs $r = 0.75$ (95% CI: 0.47 to 0.87)	-	
			3-5.99 METs $r = 0.79$ (95% CI: 0.69 to 0.88)	-	
			2-2.99 METs $r = 0.58$ (95% CI: 0.42 to -0.72)	-	
			Total: mean difference = 436, LOA = $436 \pm 1.96 \times 1260$ (min/2 weeks)		
			Mild: mean difference = 309, LOA = $309 \pm 1.96 \times 1004$ (min/2 weeks)		
			Moderate: mean difference = 102, LOA = $102 \pm 1.96 \times 436$ (min/2 weeks)		
			Vigorous: mean difference = 23, LOA = $23 \pm 1.96 \times 258$ (min/2 weeks)		

Nordic Physical Activity Questionnaire (NPAQ-short) ⁴⁷	105; N.R.; N.R.	2 weeks	MVPA open questions $\rho = 0.82^{***}$	+	-
			VPA open questions $\rho = 0.80^{***}$	+	
			MVPA close questions weighted $\kappa = 0.66$ (95% CI: 0.55 to 0.75)	-	
			VPA close questions weighted $\kappa = 0.59$ (95% CI: 0.47 to 0.69)	-	
Self-report physical activity questionnaire (SPAQ) ⁴⁸	150; 73.3% women; 60- over 80 years	1 week	MET hours/week:		+
			Total physical activity $r = 0.93^*$ (95% CI: 4.99 to 11.22)	+	
			LPA $r = 0.91^{**}$ (95% CI: -1.35 to 6.63)	+	
			MPA $r = 0.94^{**}$ (95% CI: -7.59 to -3.34)	+	
			Household physical activity $r = 0.90^{**}$ (95% CI: -6.07 to -2.76)	+	
			Occupational physical activity $r = 0.69^{**}$ (95% CI: -4.88 to -2.02)	-	
			Leisure time recreation $r = 0.87^{**}$ (95% CI: 6.4 to 11.79)	+	
			Leisure time exercise $r = 0.96^{**}$ (95% CI: -1.08 to 1.19)	+	
			Transportation physical activity $r = 0.91^*$ (95% CI: -2.94 to 4.62)	+	

Transport and Physical Activity Questionnaire (TPAQ) ⁴⁹	166; 53.3% female, <30-≥65 years	12.4 ± 6.6 days	For time spent in transport-related and recreational physical activity:	-
			Walking for transport <i>ICC</i> = 0.59 (95% CI: 0.48 to 0.68)	-
			Cycling for transport <i>ICC</i> = 0.61 (95% CI: 0.50 to 0.70)	-
			Walking for recreation <i>ICC</i> = 0.48 (95% CI: 0.35 to 0.59)	-
			Cycling for recreation <i>ICC</i> = 0.35 (95% CI: 0.20 to 0.47)	-
			Moderate Leisure time physical activity <i>ICC</i> = 0.47 (95% CI: 0.34 to 0.58)	-
			Vigorous Leisure time physical activity <i>ICC</i> = 0.63 (95% CI: 0.53 to 0.71)	-
			Total physical activity <i>ICC</i> = 0.56 (95% CI: 0.45 to 0.66)	-
			For frequency of participation in recreational physical activity:	
			Walking for recreation <i>ICC</i> = 0.80 (95% CI: 0.73 to 0.85)	+
			Cycling for recreation <i>ICC</i> = 0.63 (95% CI: 0.53 to 0.71)	-
			Moderate intensity Leisure time physical activity <i>ICC</i> = 0.13 (95% CI: 0.02 to 0.28)	-
			Vigorous intensity Leisure time physical activity <i>ICC</i> = 0.52 (95% CI: 0.40 to 0.62)	-

			Meet physical activity Guideline's $\kappa = 0.60$	-
General Practice Physical Activity Questionnaire (GPPAQ) ⁵⁰	126; N.R.; N.R.	3 months	Agreement = 56%	-
			Weighted $\kappa = 0.57$	-
		12 months	Agreement = 67%	
			Weighted $\kappa = 0.63$	-
Sedentary Behaviour				
International Physical Activity Questionnaire - Sedentary Behavior (IPAQ-SB) ⁵¹	257; 58% women; N.R.	3 to 7 days	Short Form:	-
			Weekday $\rho = 0.79$	-
			Weekend $\rho = 0.84$	+
			Total $\rho = 0.85$	+
	255; 56% women; N.R.		Long Form:	+
			Weekday $\rho = 0.81$	+
			Weekend $\rho = 0.84$	+

			Total $\rho = 0.82$	+	
Australian Longitudinal Study on Women's Health - Sedentary Behavior Questions (ALSWH - SBQ) ⁵²	157 women; N.R.	7–28 days	Weekday:		-
			Transport $r = 0.43$;	-	
			Occup $ICC = 0.79$ (95% CI: 0.73 - 0.84)	+	
			TV $r = 0.79$	-	
			Computer $ICC = 0.63$ (95% CI: 0.52 - 0.71)	-	
			Other leisure $r = 0.34$	-	
			Weekend day:		
			Transport $r = 0.31$	-	
			Occup $r = 0.53$	-	
			TV $r = 0.57$	-	
			Computer $ICC = 0.72$ (95% CI: 0.64 to 0.79)	+	

		Other leisure $r = 0.31$	-
96 men; N.R.	7–28 days	Weekday:	
		Transport $r = 0.60$	-
		Occup $ICC = 0.86$ (95% CI: 0.79 to 0.90)	+
		TV $ICC = 0.65$ (95% CI: 0.52 to 0.75)	-
		Computer $ICC = 0.62$ (95% CI: 0.48 to 0.73)	-
		Other leisure $r = 0.38$	-
		Weekend day:	
		Transport $r = 0.40$	-
		Occup $r = 0.23$	-
		TV $ICC = 0.62$ (95% CI: 0.48 to 0.73)	-
		Computer $ICC = 0.59$ (95% CI: 0.44 to 0.71)	-
		Other leisure $r = 0.32$	-

			Measurement error: Bland–Altman: Women self-report work-related sitting items on a weekday mean difference = -3.9 mins/day (LoA = -235.4 to 227.5)	?	?
			Measurement error: Bland–Altman: Women self-report work-related sitting items on a weekend day mean difference = -5.6 mins/day (LoA = -125.1 to 113.9)	?	
			Measurement error: Bland–Altman: Men self-report work-related sitting items on a weekday mean difference = -4.3 mins/day (LoA = -189.2 to 180.7)	?	
			Measurement error: Bland–Altman: Men self-report work-related sitting items on a weekend day mean difference = -8.1 mins/day (LoA = -195.0 to 178.8)	?	
Self-reported sitting and breaks from sitting in the workplace (SBSW) ⁵³	59; 54% women; 32.1± 9.9 years	7 days	Sitting <i>ICC</i> = 0.78** (95% CI: 0.65 to 0.86)	+	-
			Breaks from sitting <i>ICC</i> = 0.65** (95% CI: 0.48 to 0.78)		
Workplace Sitting Breaks Questionnaire (SITBRQ) ⁵⁴	96; 62.5% women; ~18<60 years	7-14 days	Frequency of breaks <i>rho</i> = 0.71 (95% CI: 0.59 to 0.79)	-	-
			Frequency of breaks Cohen's <i>kappa</i> = 0.74 (95% CI: 0.64 to 0.84)	+	
			Total duration of breaks <i>rho</i> = 0.59 (0.45 to 0.71)	-	
			Total duration of breaks Cohen's <i>kappa</i> = 0.61 (0.38 to 0.85)	-	
			Total duration of breaks % correctly classified = 46.9% (36.9 to 56.9)		

			Total duration of breaks % in same or adjacent category = 79.2% (71.0 to 87.3)		
			Frequency of breaks % correctly classified = 51.0% (95% CI: 41.0 to 61.0)		
			Frequency of breaks % in same or adjacent category = 85.4% (95% CI: 78.4 to 92.5)		
Sedentary Behavior Questionnaire (SBQ) ⁵⁵	49; 67% women; 20.4 ± 1.3 years	2 weeks	Weekday		+
			TV <i>ICC</i> = 0.86 (95% CI: 0.76 to 0.92)		+
			Computer games <i>ICC</i> = 0.83 (95% CI: 0.71 to .90)		+
			Sit listen to music <i>ICC</i> = 0.71 (95% CI: 0.50 to 0.82)		+
			Sit talk on telephone <i>ICC</i> = 0.81 (95% CI: 0.68 to 0.89)		+
			Office/paperwork <i>ICC</i> = 0.77 (95% CI: 0.63 to 0.86)		+
			Reading <i>ICC</i> = 0.64 (95% CI: 0.44 to 0.78)		-
			Playing musical instrument <i>ICC</i> = 0.90 (95% CI: 0.82 to 0.94)		+
			Arts and crafts <i>ICC</i> = 0.70 (95% CI: 0.53 to 0.82)		+
			Sitting driving in car <i>ICC</i> = 0.76 (95% CI: 0.61 to 0.86)		+

				Total scale <i>ICC</i> = 0.85 (95% CI: 0.75 to 0.91)	+	
				Weekend		
				TV <i>ICC</i> = 0.83 (95% CI: 0.72 to 0.90)	+	
				Computer games <i>ICC</i> = 0.80 (95% CI: 0.67 to 0.88)	+	
				Sit listen to music <i>ICC</i> = 0.67 (95% CI: 0.49 to 0.80)	-	
				Sit talk on telephone <i>ICC</i> = 0.73 (95% CI: 0.57 to 0.84)	+	
				Office/paperwork <i>ICC</i> = 0.64 (95% CI: 0.44 to 0.61)	-	
				Reading <i>ICC</i> = 0.48 (95% CI: 0.24 to 0.67)	-	
				Playing musical instrument <i>ICC</i> = 0.93 (95% CI: 0.87 to 0.96)	+	
				Arts and crafts <i>ICC</i> = 0.51 (95% CI: 0.27 to 0.69)	-	
				Sitting driving in car <i>ICC</i> = 0.72 (95% CI: 0.56 to 0.83)	+	
				Total scale <i>ICC</i> = 0.77 (95% CI: 0.63 to 0.86)	+	
SED-GIH ⁵⁶	95; 69,5% women; 70.3 ± 5.0 years	Mean = 5.2 days	SED-GIH question <i>ICC</i> = 0.86 (CI = 0.79 to 0.90)	+		+

Workforce Sitting Questionnaire (WSQ) ⁵⁷	91; N.R.; N.R.	1 week	Agreement between the two SED-GIH question answering occasions weighted <i>Kappa</i> = 0.77 (CI = 0.68 to 0.86)	+
			Workday	-
			Transport <i>ICC</i> = 0.67 (95% CI: 0.54 to 0.77)	-
			At work <i>ICC</i> = 0.63 (95% CI: 0.49 to 0.74)	-
			Watching TV <i>ICC</i> = 0.91 (95% CI: 0.87 to 0.94)	+
			Computer at home <i>ICC</i> = 0.56 (95% CI: 0.40 to 0.69)	-
			Other leisure activities <i>ICC</i> = 0.68 (95% CI: 0.55 to 0.78)	-
			Total, all domains <i>ICC</i> = 0.65 (95% CI: 0.51 to 0.75)	-
			Non-Workday:	
			Transport <i>ICC</i> = 0.60 (95% CI: 0.45 to 0.72)	-
			At work <i>ICC</i> = 0.50 (95% CI: 0.33 to 0.64)	-
			Watching TV <i>ICC</i> = 0.79 (95% CI: 0.69 to 0.85)	+

Japanese-Language Self-reported Measures for Assessing Adults Domain-Specific Sedentary Time (JSRM - SB) ⁵⁸	34; 41.2% women; 40.3 ± 11.4 years	2 weeks	Computer at home <i>ICC</i> = 0.81 (95% CI: 0.73 to 0.87)	+
			Other leisure activities <i>ICC</i> = 0.59 (95% CI: 0.44 to 0.71)	-
			Total, all domains <i>ICC</i> = 0.80 (95% CI: 0.72 to 0.87)	+
			Average total, work and non-workdays <i>ICC</i> = 0.76 (95% CI: 0.66 to 0.83)	+
			Workday	-
			Car <i>ICC</i> = 0.85** (95% CI: 0.71 to 0.92)	+
			Public transport <i>ICC</i> = 0.60** (95% CI: 0.33 to 0.78)	-
			Work <i>ICC</i> = 0.89** (95% CI: 0.80 to 0.95)	+
			TV <i>ICC</i> = 0.76** (95% CI: 0.58 to 0.88)	+
			Computer use <i>ICC</i> = 0.72** (95% CI: 0.51 to 0.85)	+
			Leisure <i>ICC</i> = 0.45** (95% CI: 0.15 to 0.68)	-
			Total <i>ICC</i> = 0.77** (95% CI: 0.60 to 0.88)	+

Non-Workday

Car *ICC* = 0.53** (95% CI: 0.24 to 0.74) -

Public transport *ICC* = 0.20 (95% CI: -0.15 to 0.50) -

Work *ICC* = -0.07 (95% CI: -0.40 to 0.28) -

TV *ICC* = 0.79** (95% CI: 0.63 to 0.89) +

Computer use *ICC* = 0.72** (95% CI: 0.51 to 0.85) +

Leisure *ICC* = 0.46** (95% CI: 0.14 to 0.69) -

Total *ICC* = 0.53** (95% CI: 0.24 to 0.73) -

Whole week

Car *ICC* = 0.83** (95% CI: 0.69 to 0.91) +

Public transport *ICC* = 0.47** (95% CI: 0.17 to 0.70) -

Work *ICC* = 0.83** (95% CI: 0.69 to 0.91) +

TV *ICC* = 0.82** (95% CI: 0.67 to 0.91) +

			Computer use $ICC = 0.74^*$ (95% CI: 0.54 to 0.86)	+	
			Leisure $ICC = 0.53^{**}$ (95% CI: 0.25 to 0.73)	-	
			Total $ICC = 0.74^{**}$ (95% CI: 0.55 to 0.86)	+	
Longitudinal Aging Study Amsterdam questionnaire (LASA) ⁵⁹	63; N.R. but not different from validity ($p > 0.27$)	23 ± 8 days	Total ST (6 items) $ICC = 0.71$ (95% CI 0.57 to 0.81).	+	+
SB question of the Yale Physical Activity Survey (YPAS - SB) ⁶⁰	58; 79% women; 66 – 88 years	10 days	Sitting $ICC = 0.59^{**}$	-	-
Community Health Activities Model Program for Seniors SB questions (CHAMPS - SB) ⁶⁰	58; 79% women; 66 – 88 yr	10 days	Sitting $ICC = 0.64^{**}$	-	-
Cancer Prevention Study-3 Sedentary Time Survey (CPS-3 sitting time) ⁶¹	713; % women; 31-72 years	1 yr	Total Sitting $\rho = 0.67$ (95% CI: 0.63 to 0.71)	-	-
			TV $\rho = 0.74$ (95% CI: 0.70 to 0.77)	-	
			Other sitting $\rho = 0.71$ (95% CI: 0.67 to 0.74)	-	
Sleep					
BRFSS sleep questions (BRFSS Sleep) ⁶²	300; 68% women; 18-96 years	14 days	Comparing first measure to 14 days, Cronbach α was 0.76 ($F = 0.31$, $df = 114$, $p = 0.57$).	?	?
		30 days	Comparing first measure to 30 days, Cronbach α was 0.85 ($F = 4.96$, $df = 135$, $p = 0.03$)	?	
Physical Activity + Sedentary Behaviour					

Kaiser Physical Activity Survey (KPAS) ⁶³	50 women; 20-60 years	1 month	Caregiving score <i>ICC</i> = 0.01	-	+
			Housework score <i>ICC</i> = 0.79	+	
			Housework/caregiving score <i>ICC</i> = 0.81	+	
			Sports/exercise <i>ICC</i> = 0.84	+	
			Active living habits <i>ICC</i> = 0.82	+	
			Occupation <i>ICC</i> = 0.85	+	
			3-point summary <i>ICC</i> = 0.82	+	
			4-point summary <i>ICC</i> = 0.84	+	
Sedentary, Transportation and Activity Questionnaire (STAQ) ⁶⁴	32; 53.1 % women; 20-62 years	1 month	SB:		-
			Total ST <i>ICC</i> = 0.52 (95% CI: 0.22 to 0.73)	-	
			Work <i>ICC</i> = 0.71 (95% CI: 0.49 to 0.84)	+	
			Transport <i>ICC</i> = 0.28 (95% CI: -0.06 to 0.56)	-	
			Leisure Time <i>ICC</i> = 0.37 (95% CI: 0.03 to 0.62)	-	

Leisure SB:

Total *ICC* = 0.64 (95% CI: 0.38 to 0.80) -

Total screen time *ICC* = 0.70 (95% CI: 0.48 to 0.84) +

Tv/DVD *ICC* = 0.79 (95% CI: 0.61 to 0.89) +

Computer/tablet/video games *ICC* = 0.64 (0.38 to 0.80) -

Reading, writing, listening to music, sewing
ICC = 0.26 (95% CI: -0.08 to 0.55) -

Transport-related activities:

Active transport:

Walking *ICC* = 0.61 (95% CI: 0.35 to 0.79) -

Walking + cycling *ICC* = 0.47 (95% CI: 0.16 to 0.70) -

Passive transport:

All transportation type *ICC* = 0.50 (95% CI: 0.20 to 0.72) -

Car *ICC* = 0.67 (95% CI: 0.42 to 0.82) -

International Physical Activity Questionnaire (IPAQ) ⁶⁵	Short form past week: 19-151; N.R.; 18-65 years	8-10 days	TEE ρ = 0.66 to 0.88	+	+
			ST ρ = 0.71 to 0.95	+	
			Guideline's compliance % = 93 to 100		
	Short form usual week: 28-257; N.R.; 18-65 years	8-10 days	TEE ρ = 0.65 to 0.84	+	+
			ST ρ = 0.58 to 0.94	+	
			Guideline's compliance % = 77 to 99		
	Long form past week: 19-149; N.R.; 18-65 years	8-10 days	TEE ρ = 0.70 to 0.91	+	+
			ST ρ = 0.74 to 0.89	+	
			Guideline's compliance % = 92 to 100		
	Long form usual week: 28-255; N.R.; 18-65 years	8-10 days	TEE ρ = 0.69 to 0.93	+	+
			ST ρ = 0.74 to 0.93	+	
			Guideline's compliance % = 90 to 100		
Australian Women's Activity Survey (AWAS) ⁶⁶	40 women; 33 $\pm$ 5 years	1 week	Sitting Time ICC = 0.42 (0.13 to 0.64)	-	-

			LPA ICC = 0.66 (0.43 to 0.81)	-
			MPA = 0.74 (0.56 to 0.85)	+
			Vigorous physical activity = 0.66 (0.43 to 0.80)	-
			Total Activity = 0.73 (0.51 to 0.86)	+
Workers' sitting- and walking-time questionnaire Time Method (WSWQ-t-method) ⁶⁷	64; 40% women; men mean age: 46.3 ± 8.0 years; women mean age: 35.8 ± 7.5 years	1 week	Workday:	-
			During working time:	
			Sitting ICC = 0.85 (95% CI: 0.76 to 0.91)	+
			Walking/Standing ICC = 0.83 (95% CI: 0.73 to 0.89)	+
			During non-working time	
			Sitting ICC = 0.49 (95% CI: 0.28 to 0.66)	-
			Walking/Standing ICC = 0.56 (95% CI: 0.37 to 0.71)	-
			Non-workday:	
		Sitting ICC = 0.64 (95% CI: 0.47 to 0.76)	-	

			Walking/Standing <i>ICC</i> = 0.48 (95% CI: 0.27 to 0.65)	-	
The Physical Activity Scale for the Elderly (PASE) ⁶⁸	254; N.R.; N.R.	3-7 week	PASE activity score <i>r</i> = 0.84	+	+
Community Health Activities Model Program for Seniors physical activity self-report questionnaire + transport items (CHAMPS+transport) ⁶⁹	748; N.R.; N.R.	6 months	Low-LPA <i>ICC</i> = 0.70	+	-
			High-LPA <i>ICC</i> = 0.68	-	
			MVPA <i>ICC</i> = 0.66	-	
			Total PA duration <i>ICC</i> = 0.69	-	
			MVPA caloric expenditure <i>ICC</i> = 0.61	-	
			Total physical activity caloric expenditure <i>ICC</i> = 0.64	-	
			Sedentary time <i>ICC</i> = 0.56	-	
Community Healthy Activities Model Program for Seniors (CHAMPS) ⁷⁰	249; 63.9% women; 65 - 90 years	6 months	Caloric expenditure per week in at least moderate intensity physical activities <i>ICC</i> = 0.67	-	-
			Frequency per week in at least moderate intensity physical activities <i>ICC</i> = 0.58 (0.60)	-	
			Caloric expenditure per week in all listed physical activities <i>ICC</i> = 0.66	-	

			Frequency per week in all listed physical activities <i>ICC</i> = 0.62	-	
Modified Version of the MONICA Optional Study on Physical Activity Questionnaire (Modified MOSPA-Q) ⁷¹	75; N.R.; N.R.	1 week	Walking <i>ICC</i> = 0.89 (95% CI = 0.84 to 0.93)	+	-
			Lifting/Carrying <i>ICC</i> = 0.82 (95% CI = 0.73 to 0.88)	+	
			Standing <i>ICC</i> = 0.64 (95% CI = 0.48 to 0.75)	-	
			Sitting <i>ICC</i> = 0.54 (95% CI = 0.36 to 0.68)	-	
Occupational Sitting and Physical Activity Questionnaire (OSPAQ) ^{71,72}	84; N.R.; N.R.	1 week	Walking <i>ICC</i> = 0.73 (95% CI = 0.62 to 0.82)	+	+
			Heavy Work <i>ICC</i> = 0.97 (95% CI = 0.96 to 0.98)	+	
			Standing <i>ICC</i> = 0.90 (95% CI = 0.85 to 0.93)	+	
			Sitting <i>ICC</i> = 0.89 (95% CI = 0.83 to 0.92)	+	
	75; 82.7% women; 42.87 ± 11.34 years	1 week	Walking <i>ICC</i> = 0.01 (95% CI = -0.21 to 0.23)	-	-
			Standing <i>ICC</i> = 0.37 (95% CI = 0.17 to 0.54)	-	
			Sitting <i>ICC</i> = 0.44 (95% CI = 0.24 to 0.60)	-	
Rapid Assessment Disuse Index (RADI) ⁷³	157; N.R.; N.R.	12-16 days	Total physical activity:		-

Week <i>ICC</i> = 0.73 (95% CI = 0.64 to 0.79)	+
Month <i>ICC</i> = 0.67 (95% CI = 0.57 to 0.75)	-
Year <i>ICC</i> = 0.67 (95% CI = 0.57 to 0.74)	-
Stairs:	
Week <i>ICC</i> = 0.74 (95% CI = 0.65 to 0.80)	+
Month <i>ICC</i> = 0.64 (95% CI = 0.54 to 0.73)	-
Year <i>ICC</i> = 0.59 (95% CI = 0.48 to 0.68)	-
Sitting Time:	
Week <i>ICC</i> = 0.56 (95% CI = 0.44 to 0.67)	-
Month <i>ICC</i> = 0.58 (95% CI = 0.46 to 0.67)	-
Year <i>ICC</i> = 0.60 (95% CI = 0.49 to 0.69)	-
RADI scores:	
Wk <i>ICC</i> = 0.76 (95% CI = 0.70 to 0.83)	+

Global Physical Activity Questionnaire 148; N.R.; N.R. (GPAQ) ⁷⁴	Month <i>ICC</i> = 0.74 (95% CI = 0.65 to 0.80)	+	
	Year <i>ICC</i> = 0.71 (95% CI = 0.62 to 0.78)	+	
	Cumulative RADI score <i>ICC</i> = 0.79 (0.73–0.85)	+	
	3 to 7 days Work Domain (categorical)		+
	Sedentary <i>kappa</i> (agreement) = 0.74 (87.8%)	+	
	Vigorous intensity <i>kappa</i> (agreement) = 0.88 (97.9%)	+	
	Moderate intensity <i>kappa</i> (agreement) = 0.87 (94.6%)	+	
	Transport: walking and cycling <i>kappa</i> (agreement) = 0.75 (91.2%)	+	
	Leisure Domain (categorical):		
	Sedentary <i>kappa</i> (agreement)= 0.82 (91.6%)	+	
	Vigorous intensity <i>kappa</i> (agreement)= 0.89 (95.9%)	+	
	Moderate intensity <i>kappa</i> (agreement)= 0.88 (94.6%)	+	
	Work Domain (continuous)		

			Vigorous intensity $\rho = 0.88^{**}$	+	
			Moderate intensity $\rho = 0.85^{**}$	+	
			Work total $\rho = 0.83^{**}$	+	
			Transport total $\rho = 0.90^{**}$	+	
			Leisure domain		
			Vigorous intensity $\rho = 0.89^{**}$	+	
			Moderate intensity $\rho = 0.83^{**}$	+	
			Total $\rho = 0.88^{**}$	+	
Sedentary Behaviour + Sleep					
SIT-Q ⁷⁵	64; N.R.; N.R.	1 month	Meals $ICC = 0.60$ (95% CI: 0.42 to 0.74)	-	-
			Transportation $ICC = 0.59$ (95% CI: 0.41 to 0.73)	-	
			Occup = 0.86 (95% CI: 0.78 to 0.91)	+	
			Child and elder care $ICC = 0.59$ (95% CI: 0.40 to 0.73)	-	

TV ICC = 0.84 (0.75 - 0.90)	+
Computer use ICC = 0.31 (0.07 - 0.52)	-
Leisure Time ICC = 0.61 (0.43 - 0.74)	-
Total sitting time ICC = 0.65 (0.49 - 0.78)	-
Categorical question: How often did you “break up” the time you spent sitting during their primary “job” absolute agreement = 55%	
weighted kappa = 0.49	-
Categorical question: breaking up time spent sitting whilst watching television agreement = 61%	
wk = 0.50	-
Categorical question: how often participants ate snack foods whilst watching television agreement = 56	

			wk = 0.48	-	
			Measurement error: Bland Altman: total sitting time (h/day): 95% LoA: 3.62 to 4.6; Overall, participants tended to report shorter periods of sedentary behaviour in the second administration of the SIT-Q.	?	?
Physical Activity + Sedentary Behaviour + Sleep					
Physical Activity Questionnaire (PAQ) ⁷⁶	111 men; N.R.	6 months	Crude Total physical activity $\rho = 0.65^*$	-	-
			Total activity score $\rho = 0.65^*$	-	
			work/occupation $\rho = 0.68^*$	-	
			home/household $\rho = 0.64^*$	-	
			activity leisure-time $\rho = 0.68^*$	-	
			inactive leisure (TV/reading) $\rho = 0.68^*$	-	
			sleep $\rho = 0.76^*$	-	
Athens Physical Activity Questionnaire (APAQ) ⁷⁷	60; 67% women; 21 $\pm$ 2 years	7 to 14 days	Total EEXP ICC = 0.95 (95% CI: 0.92 to 0.97)*	+	+
			Occupational EEXP ICC = 0.78 (95% CI: 0.65 to 0.86)*	+	

Sedentary Time and Activity Reporting Questionnaire (STAR-Q) ⁷⁸	95; N.R.; N.R.	3 months	Home EEXP <i>ICC</i> = 0.58 (95% CI: 0.38 to 0.73)*	-	
			Recreational EEXP <i>ICC</i> = 0.85 (95% CI: 0.76 to 0.91)*	+	
			TEE, kcal/day <i>ICC</i> = 0.84 (95% CI: 0.77 - 0.89)	+	-
			AEE, kcal/day <i>ICC</i> = 0.73 (95% CI: 0.62 - 0.81)	+	
			Sleeping <i>ICC</i> = 0.79 (95% CI: 0.70 - 0.85)	+	
			Stair-climbing, flights/day <i>ICC</i> = 0.45 (95% CI: 0.28 - 0.60)	-	
			Active sitting <i>ICC</i> = 0.45 (95% CI: 0.28 - 0.60)	-	
			Overall Activity:		
			SB <i>ICC</i> = 0.53 (95% CI: 0.37 - 0.66)	-	
			Light intensity <i>ICC</i> = 0.60 (95% CI: 0.46 - 0.71)	-	
			Moderate intensity <i>ICC</i> = 0.45 (95% CI: 0.28 - 0.60)	-	
			Vigorous intensity <i>ICC</i> = 0.65 (95% CI: 0.52 - 0.75)	-	
			Exercise, sports, and leisure activity		

General <i>ICC</i> = 0.63 (95% CI: 0.49 - 0.74)	-
Light intensity <i>ICC</i> = 0.44 (95% CI: 0.26 - 0.59)	-
Mod intensity <i>ICC</i> = 0.42 (95% CI: 0.24 - 0.57)	-
Vig intensity <i>ICC</i> = 0.59 (95% CI: 0.44 - 0.71)	-
Occup activity:	
General <i>ICC</i> = 0.76 (95% CI: 0.66 - 0.83)	+
Sitting <i>ICC</i> = 0.69 (95% CI: 0.57 - 0.78)	-
SB <i>ICC</i> = 0.71 (95% CI: 0.60 - 0.80)	+
Light intensity <i>ICC</i> = 0.65 (95% CI: 0.52 - 0.75)	-
Mod intensity <i>ICC</i> = 0.44 (95% CI: 0.26 - 0.59)	-
Light leisure activity:	
General <i>ICC</i> = 0.65 (95% CI: 0.52 - 0.75)	-
TV <i>ICC</i> = 0.72 (95% CI: 0.61 - 0.80)	+

		Computer <i>ICC</i> = 0.60 (95% CI: 0.46 - 0.71)	-	
		Reading <i>ICC</i> = 0.56 (95% CI: 0.41 - 0.68)	-	
Question 8 of the Paffenbarger Physical Activity Questionnaire (Q 8 PPAQ) ⁷⁹	130; 51.2% women; 44.0 ± 15.8 1 week years for men, 45.3 ± 16.9 for women	Light intensity <i>ICC</i> = 0.49 (95% CI: 0.38 to 0.59)	-	-
		Light intensity SEM = 2.0		
		Moderate intensity <i>ICC</i> = 0.61 (95% CI: 0.52 to 0.68)	-	
		Moderate intensity SEM = 1.7		
		Vig intensity <i>ICC</i> = 0.67 (95% CI: 0.59 to 0.72)	-	
		VPA SEM = 1.0		
		SB <i>ICC</i> = 0.71 (95% CI: 0.61 to 0.74)	+	
		SB SEM = 1.9		
EPIC-Norfolk Physical Activity Questionnaire (EPAQ2) ⁸⁰	399; 53.13 % women; men age: 3 months 65.0 ± 8.2 years; women age: 63.8 ± 8.4 years	Men:		-

TV $\rho = 0.75$	-
TV $\kappa = 0.71$	-
Activity at home $\kappa = 0.77$	+
Activity at home $\rho = 0.61$	-
Activity at work $\rho = 0.57$	-
Activity at work $\kappa = 0.79$	+
Recreational activity $\rho = 0.69$	-
Recreational activity $\kappa = 0.54$	-
VPA $\rho = 0.75$	-
VPA $\kappa = 0.58$	-
Physical activity index $\rho = 0.74$	-
Physical activity index $\kappa = 0.66$	-
Women:	

		TV $\rho = 0.78$	-
		TV $\kappa = 0.74$	+
		Activity at home $\rho = 0.74$	-
		Activity at home $\kappa = 0.62$	-
		Activity at work $\rho = 0.37$	-
		Activity at work $\kappa = 0.82$	+
		Recreational activity $\rho = 0.64$	-
		Recreational activity $\kappa = 0.55$	-
		VPA $\rho = 0.41$	-
		VPA $\kappa = 0.67$	-
		Physical activity index $\rho = 0.72$	-
		Physical activity index $\kappa = 0.70$	+
Workers' sitting- and walking-time questionnaire Percentage Method (WSWQ - p-method) ⁶⁷	64; 40% women; men age: 46.3 $\pm$ 8.0 years; women age: 35.8 $\pm$ 7.5 years	Workday:	+

			During working time:		
			Sitting <i>ICC</i> = 0.83 (95% CI: 0.73 to 0.89)	+	
			Walking/Standing <i>ICC</i> = 0.85 (95% CI: 0.76 to 0.90)	+	
			During non-working time		
			Sitting <i>ICC</i> = 0.71 (95% CI: 0.56 to 0.81)	+	
			Walking/Standing <i>ICC</i> = 0.77 (95% CI: 0.65 to 0.85)	+	
			Non-workday:		
			Sitting <i>ICC</i> = 0.78 (95% CI: 0.66 to 0.86)	+	
			Walking/Standing <i>ICC</i> = 0.79 (95% CI: 0.68–0.87)	+	
New Questionnaire on Physical Activity (NQPA) ⁸¹	112; 44.64% women; N.R.	5 months / men	Rest <i>r</i> = 0.67 (95% CI: 0.50 to 0.79)	-	-
			Occupational <i>r</i> = 0.90 (95% CI: 0.84 to 0.94)	+	
			Leisure Time <i>r</i> = 0.85 (95% CI: 0.76 to 0.91)	+	
		5 months / women	Rest <i>r</i> = 0.65 (95% CI: 0.46 to 0.79)	-	

			Occupational $r = 0.79$ (95% CI: 0.65 to 0.87)	-	
			Leisure Time $r = 0.68$ (95% CI: 0.50 to 0.81)	-	
Web-Based Physical Activity Questionnaire (Active-Q) ⁸²	109; 47,70% women; N.R.	11 months / men	Rest $r = 0.71$ (95% CI: 0.56 to 0.82)	-	
			Occupational $r = 0.89$ (95% CI: 0.83 to 0.94)	+	
			Leisure Time $r = 0.72$ (95% CI: 0.56 to 0.82)	-	
		11 months / women	Rest $r = 0.66$ (95% CI: 0.47 to 0.79)	-	
			Occupational $r = 0.80$ (95% CI: 0.68 to 0.88)	+	
			Leisure Time $r = 0.69$ (95% CI: 0.52 to 0.81)	-	
			Measurement error: Bland-Altman: "The limits of 2 standard deviations below and above the mean difference were -3368 and 3243 kJ."	?	?
	148 men; 33-86 years	12 days	SB ICC = 0.80 (95% CI: 0.74 to 0.86)	+	-
			LPA ICC = 0.66 (95% CI: 0.57 to 0.75)	+	
			SB+LPA ICC = 0.67 (95% CI: 0.58 to 0.76)	-	
			MPA ICC = 0.69 (95% CI: 0.60 to 0.77)	-	

			VPA <i>ICC</i> = 0.51 (95% CI: 0.39 to 0.63)	-
			MVPA <i>ICC</i> = 0.67 (95% CI: 0.58 to 0.76)	-
Flemish Physical Activity Computerized Questionnaire (FPACQ) ⁸³	66 employed/unemployed: 31 men: 39.23 ± 11.65 years; 35 women: 41.46 ± 12.62 years 36 retired: 20 men: 63.65 ± 6.05 years; 16 women: 63.31 ± 3.94 years	2 weeks	Employed/Unemployed Men	+
			Time/week spent on sports participation <i>ICC</i> =	+
			0.87 (95% CI: 0.75 to 0.94)	
			Energy expenditure/week on sports	+
			participation <i>ICC</i> = 0.94 (95% CI: 0.88 to 0.97)	
			Average energy expenditure on sports	+
			participation <i>ICC</i> = 0.97 (95% CI: 0.94 to 0.98)	
			Time/week spent eating <i>ICC</i> = 0.74 (95% CI:	+
			0.53 to 0.86)	
			Time/week spent sleeping <i>ICC</i> = 0.84 (95%	+
			CI: 0.70 to 0.92)	
			Time/week spent watching television or	+
			videos or playing computer games <i>ICC</i> = 0.93	
			(95% CI: 0.86 to 0.97)	
			Time/week spent on leisure-time active	+
			transportation <i>ICC</i> = 0.75 (95% CI: 0.55 to	
			0.87)	
			Time/week spent on active leisure-time	+
			activities <i>ICC</i> = 0.79 (95% CI: 0.62 to 0.90)	
			Energy expenditure/week on active leisure	+
			time-activities <i>ICC</i> = 0.84 (95% CI: 0.70 to	
			0.92)	

Average energy expenditure on active leisure- +
time activities *ICC* = 0.90 (95% CI: 0.81 to
0.95)

Time/week spent on occupation and +
transportation to and from occupation *ICC* =
0.97 (95% CI: 0.94 to 0.99)

Energy expenditure/week on occupation and +
transportation
to and from occupation *ICC* = 0.94 (95% CI:
0.88 to 0.97)

Average energy expenditure on occupation +
and transportation to and from occupation *ICC*
= 0.95 (95% CI: 0.91 to 0.98)

Overall energy expenditure during a usual +
week *ICC* = 0.95 (95% CI: 0.89 to 0.97)

Physical activity level (MET) *ICC* = 0.92 (95% +
CI: 0.84 to 0.96)

Employed/Unemployed Women

Time/week spent on sports participation *ICC* = +
0.91 (95% CI: 0.82 to 0.95)

Energy expenditure/week on sports +
participation *ICC* = 0.91 (95% CI: 0.83 to 0.95)

Average energy expenditure on sports +
participation *ICC* = 0.74 (95% CI: 0.55 to 0.86)

Time/week spent eating *ICC* = 0.67 (95% CI: -
0.43 to 0.82)

Time/week spent sleeping *ICC* = 0.83 (95% +
CI: 0.70 to 0.91)

Time/week spent watching television or videos or playing computer games	+
<i>ICC</i> = 0.92 (95% CI: .84 to 0.96)	
Time/week spent on leisure-time active transportation	+
<i>ICC</i> = 0.71 (95% CI: 0.50 to 0.84)	
Time/week spent on active leisure-time activities	+
<i>ICC</i> = 0.85 (95% CI: 0.73 to 0.92)	
Energy expenditure/week on active leisure time-activities	+
<i>ICC</i> = 0.86 (95% CI: 0.75 to 0.93)	
Average energy expenditure on active leisure-time activities	+
<i>ICC</i> = 0.94 (95% CI: 0.88 to 0.97)	
Time/week spent on occupation and transportation to and from occupation	+
<i>ICC</i> = 0.99 (95% CI: 0.98 to 0.99)	
Energy expenditure/week on occupation and transportation to and from occupation	+
<i>ICC</i> = 0.97 (95% CI: 0.94 to 0.98)	
Average energy expenditure on occupation and transportation to and from occupation	+
<i>ICC</i> = 0.98 (95% CI: 0.96 to 0.99)	
Overall energy expenditure during a usual week	+
<i>ICC</i> = 0.92 (95% CI: 0.85 to 0.96)	
Physical activity level (MET)	+
<i>ICC</i> = 0.78 (95% CI: 0.61 to 0.88)	

Retired Men

Time/week spent on sports participation	$ICC = 0.68$ (95% CI: 0.37 to 0.86)	-
Energy expenditure/week on sports participation	$ICC = 0.68$ (95% CI: 0.36 to 0.86)	-
Average energy expenditure on sports participation	$ICC = 0.60$ (95% CI: 0.23 to 0.82)	-
Time/week spent eating	$ICC = 0.24$ (95% CI: 0.20 to 0.61)	-
Time/week spent sleeping	$ICC = 0.94$ (95% CI: 0.86 to 0.98)	+
Time/week spent watching television or videos or playing computer games	$ICC = 0.76$ (95% CI: 0.49 to 0.89)	+
Time/week spent on leisure-time active transportation	$ICC = 0.81$ (95% CI: 0.58 to 0.92)	+
Time/week spent on active leisure-time activities	$ICC = 0.83$ (95% CI: 0.62 to 0.93)	+
Energy expenditure/week on active leisure time-activities	$ICC = 0.83$ (95% CI: 0.63 to 0.93)	+
Average energy expenditure on active leisure-time activities	$ICC = 0.71$ (95% CI: 0.41 to 0.87)	+
Overall energy expenditure during a usual week	$ICC = 0.90$ (95% CI: 0.76 to 0.96)	+
Physical activity level (MET)	$ICC = 0.89$ (95% CI: 0.76 to 0.96)	+

Retired Women

Time/week spent on sports participation *ICC* = +
0.92 (95% CI: 0.79 to 0.97)

Energy expenditure/week on sports +
participation *ICC* = 0.91 (95% CI: 0.78 to 0.97)

Average energy expenditure on sports +
participation *ICC* = 0.94 (95% CI: 0.84 to 0.98)

Time/week spent eating *ICC* = 0.14 (95% CI: - -
0.35 to 0.58)

Time/week spent sleeping *ICC* = 0.90 (95% +
CI: 0.75 to 0.97)

Time/week spent watching television or +
videos or playing computer games *ICC* = 0.89
(95% CI: 0.72 to 0.96)

Time/week spent on leisure-time active -
transportation *ICC* = 0.57 (95% CI: 0.14 to
0.83)

Time/week spent on active leisure-time -
activities *ICC* = 0.64 (95% CI: 0.24 to 0.85)

Energy expenditure/week on active leisure +
time-activities *ICC* = 0.71 (95% CI: 0.35 to
0.89)

Average energy expenditure on active leisure- +
time activities *ICC* = 0.77 (95% CI: 0.48 to
0.91)

Overall energy expenditure during a usual +
week *ICC* = 0.96 (95% CI: 0.90 to 0.99)

Physical activity level (MET) /CC = 0.77 (95% +
CI: 0.47 to 0.91)

Table 4. abbreviations: n= Sample Number; SD= Standard Deviation; N.R.= Not Reported; VPA= Vigorous Physical Activity; MPA= Moderate Physical Activity; MVPA= Moderate-Vigorous Physical Activity; MET= Metabolic Equivalent Task; /CC= Intraclass Correlations; LoA= Limits of Agreement; SEM= Standard Error of Measurement; * p≤0.05; ** p≤0.001; ***p≤0.0001; ? =Doubtful; + = Adequate; - = Inadequate

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4.2.6. Supplementary work 6 – Responsiveness

Tablel S4. Responsiveness Results

Questionnaire	Sample	Responsiveness		Quality of validity results	Overall Quality
	n; % Women; Age mean $\pm$ SD or Age range (years)	Type	Results		
Community Healthy Activities Model Program for Seniors (CHAMPS) ⁷⁰	164; N.R.	Comparison between subgroups	Caloric expenditure per week in, at least, moderate intensity physical activities effect size = 0.38; F test = $F_{1,159} = 8.84$, $p = 0.003$. Within group change: Intervention 487 calories ($t=3.65$, $p < 0.001$), Control 5 calories (NS)	+	+
			Frequency per week in, at least, moderate intensity physical activities effect size = 0.54; F test = $F_{1,159} = 6.55$, $p = 0.01$; Within group change: Intervention 3.1 calories ($t=5.55$, $p < 0.001$), Control 0.99 calories (NS)	+	
			Caloric expenditure per week in all listed physical activities effect size = 0.42; F test = $F_{1,159} = 9.06$, $p = 0.003$; Within group change: Intervention 687 calories ($t=3.67$, $p < 0.001$), Control 210 calories (NS)	+	
			Frequency per week in all listed physical activities effect size = 0.64; F test = $F_{1,159} = 16.39$, $p = 0.0001$; Within group change: Intervention 5.18 calories ($t=6.80$, $p < 0.001$), Control 0.58 calories (NS)	+	

Abbreviations: n= Sample Number; SD= Standard Deviation; NS= Not significant; N.R.= Not reported

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4.2.7. Supplementary work 7 - Risk of bias

Table S5. Risk of Bias of Criterion Validity

Questionnaire	Statistical Methods		Overall Rating*
	1. Continuous scores: Correlations, or the area under the receiver operating curve calculated?	2.Dichotomous scores: Sensitivity and specificity determined?	
Physical Activity			
Nord-Trøndelag Health Study PA Questionnaire (HUNT 1) ³⁰	1	NA	1
Past Year Total Physical Activity Questionnaire (PYTPAQ) ³¹	1	NA	1
Physical Activity Assessment Tool (PAAT) ³²	1	1	1
Minnesota Leisure Time Physical Activity Questionnaire (Minnesota LTPA Q) ³³	1	NA	1
Single Item Physical Activity Measure (SI PA M) ³⁴	NA	NA	NA
Godin Questionnaire (Godin Q) ³³	1	NA	1
CARDIA Physical Activity History (CARDIA) ³³	1	NA	1
College Alumnus Questionnaire (College Alumnus Q) ³³	1	NA	1

Minnesota Heart Health Program Questionnaire (MHHP Q) ³³	1	NA	1
Modified Historical Leisure Activity Questionnaire (MHLAQ) ³⁵	NA	NA	NA
Modified version Active Australia Survey 1(MV – AAS1) ³⁶	1	4	4
Modified version Active Australia Survey (MV – AAS2) ³⁷	1	4	4
Adapted from Active Australia Survey (Adapt AAS) ³⁸	1	4	4
International Physical Activity Questionnaire – Walking Section (IPAQ-WS) ³⁹	1	NA	1
Short Questionnaire to Assess Health-enhancing physical activity (SQUASH) ⁴⁰	1	NA	1
European Prospective Investigation into Cancer and Nutrition Physical Activity Questionnaire (EPIC PAQ) ⁴¹	1	4	4
13-Item Physical Activity Questionnaire (13I-PAQ) ⁴²	NA	NA	NA
Questionnaire d'Activité Physique pour les Personnes Âgées (QAPPA) ⁴³	NA	NA	NA
Incidental and Planned Exercise Questionnaire (IPEQ) ⁴⁴	NA	NA	NA
Physical Activity Questionnaire for Elderly Japanese (PAQ-EJ) ⁴⁵	1	4	4
The Longitudinal Ageing Study Amsterdam Physical Activity Questionnaire (LAPAQ) ⁴⁶	1	NA	1
Nordic Physical Activity Questionnaire (NPAQ-short) ⁴⁷	1	1	1
Self-report physical activity questionnaire (SPAQ) ⁴⁸	1	NA	1

Transport and Physical Activity Questionnaire (TPAQ) ⁴⁹	1	NA	1
General Practice Physical Activity Questionnaire (GPPAQ) ⁵⁰	4	1	4
Sedentary Behaviour			
International Physical Activity Questionnaire - Sedentary Behaviour (IPAQ-SB) ⁵¹	1	NA	1
Australian Longitudinal Study on Women's Health - Sedentary Behaviour Questions (ALSWH - SB Q) ⁵²	NA	NA	NA
Self-reported sitting and breaks from sitting in the workplace (SBSW) ⁵³	1	NA	1
Workplace Sitting Breaks Questionnaire (SITBRQ) ⁵⁴	1	NA	1
Sedentary Behavior Questionnaire (SBQ) ⁵⁵	1	NA	1
SED-GIH ⁵⁶	1	NA	1
Workforce Sitting Questionnaire (WSQ) ⁵⁷	1	NA	1
Japanese-Language Self-reported Measures for Assessing Adults Domain-Specific Sedentary Time (JSRM - SB) ⁵⁸	1	NA	1
Longitudinal Aging Study Amsterdam questionnaire (LASA) ⁵⁹	1	NA	1
SB question of the Yale Physical Activity Survey (YPAS - SB) ⁶⁰	1	NA	1
Community Health Activities Model Program for Seniors SB questions (CHAMPS - SB) ⁶⁰	1	NA	1
Cancer Prevention Study-3 Sedentary Time Survey (CPS-3 ST) ⁶¹	1	NA	1
Sleep			
BRFSS sleep questions (BRFSS Sleep) ⁶²	4	NA	4
Physical Activity + Sedentary Behaviour			

Kaiser Physical Activity Survey (KPAS) ⁶³	1	NA	1
Sedentary, Transportation and Activity Questionnaire (STAQ) ⁶⁴	1	NA	1
International Physical Activity Questionnaire (IPAQ) ⁶⁵	1	1	1
Australian Women's Activity Survey (AWAS) ⁶⁶	1	NA	1
Workers' sitting- and walking-time questionnaire Time Method (WSWQ- t-method) ⁶⁷	1	NA	1
The Physical Activity Scale for the Elderly (PASE) ⁶⁸	NA	NA	NA
Community Health Activities Model Program for Seniors physical activity self-report questionnaire + transport items (CHAMPS+transport) ⁶⁹	1	NA	1
Community Healthy Activities Model Program for Seniors (CHAMPS) ⁷⁰	NA	NA	NA
Modified Version of the MONICA Optional Study on Physical Activity Questionnaire (Modified MOSPA-Q) ⁷¹	1	NA	1
Occupational Sitting and Physical Activity Questionnaire (OSPAQ) ^{71,72}	1	NA	1
Rapid Assessment Disuse Index (RADI) ⁷³	1	NA	1
Global Physical Activity Questionnaire (GPAQ) ⁷⁴	1	1	1
Sedentary Behaviour + Sleep			
SIT-Q ⁷⁵	NA	NA	NA
Physical Activity + Sedentary Behaviour + Sleep			
Physical Activity Questionnaire (PAQ) ⁷⁶	NA	NA	NA
Athens Physical Activity Questionnaire (APAQ) ⁷⁷	1	NA	1
Sedentary Time and Activity Reporting Questionnaire (STAR-Q) ⁷⁸	NA	NA	NA

Question 8 of the Paffenbarger Physical Activity Questionnaire (Q 8 PPAQ) ⁷⁹	1	NA	1
EPIC-Norfolk Physical Activity Questionnaire (EPAQ2) ⁸⁰	1	NA	1
Workers' sitting- and walking-time questionnaire Percentage Method (WSWQ - p-method) ⁶⁷	1	NA	1
New Questionnaire on Physical Activity (NQPA) ⁸¹	NA	NA	NA
Web-Based Physical Activity Questionnaire (Active-Q) ⁸¹	1	NA	1
Flemish Physical Activity Computerized Questionnaire (FPACQ) ⁸³	1	NA	1

Table S6. Risk of Bias of Reliability and Measurement Error

Questionnaire	Design Requirements (for reliability and measurement error)			Reliability Statistical Methods			Measurement Error Statistical Methods			Overall Rating Reliability/Measurement Error*
	1.Participants stable during measurement period?	2.Time interval appropriate?	3.Similar test conditions in both measurements?	4.Continuous scores: ICC calculated?	5.Dichotomous/nominal/ordinal scores: Kappa calculated?	6.Ordinal scores: weighted kappa calculated?	7. Ordinal scores: Weighting scheme described?	4.Continuous scores: SEM, SDC or LoA calculated?	5.Dichotomous/nominal/ordinal scores: Percentage (positive and negative) agreement calculated?	
	Physical Activity									
Nord-Trøndelag Health Study PA Questionnaire (HUNT 1) ³⁰	1	1	2	3	1	1	2	N.R.	N.R.	3/N.R.
Past Year Total Physical Activity Questionnaire (PYTPAQ) ³¹	1	1	1	1	NA	NA	NA	N.R.	NA	1/N.R.
Physical Activity Assessment Tool (PAAT) ³²	1	1	1	3	1	NA	NA	N.R.	N.R.	3/N.R.
Minnesota Leisure Time Physical Activity	1	1	1	3	NA	NA	NA	N.R.	NA	3/N.R.

Questionnaire (Minnesota LTPA Q) ³³											
Single Item Physical Activity Measure (SI PA M) ³⁴	1	1	1	3	1	1	2	N.R.	N.R.	3/N.R.	
Godin Questionnaire (Godin Q) ³³	1	1	1	3	NA	NA	NA	N.R.	NA	4/N.R.	
CARDIA Physical Activity History (CARDIA) ³³	1	1	1	3	NA	NA	NA	N.R.	NA	3/N.R.	
College Alumnus Questionnaire (College Alumnus Q) ³³	1	1	1	3	NA	NA	NA	N.R.	NA	3/N.R.	
Minnesota Heart Health Program Questionnaire (MHHP Q) ³³	1	1	1	3	NA	NA	NA	N.R.	NA	3/N.R.	
Modified Historical Leisure Activity Questionnaire (MHLAQ) ³⁵	2	1	2	1	NA	NA	NA	N.R.	NA	2/N.R.	
Modified version Active Australia	1	1	1	3	4	NA	NA	2	2	4/2	

Survey 1(MV – AAS1) ³⁶										
Modified version Active Australia Survey (MV – AAS2) ³⁷	1	4	2	4	1	NA	NA	1	N.R.	4/4
Adapted from Active Australia Survey (Adapt AAS) ³⁸	1	1	2	1	1	NA	NA	N.R.	1	2/2
International Physical Activity Questionnaire – Walking Section (IPAQ-WS) ³⁹	1	1	2	4	NA	NA	NA	N.R.	NA	4/N.R.
Short Questionnaire to Assess Health-enhancing physical activity (SQUASH) ⁴⁰	1	1	1	3	1	1	1	N.R.	NA	3/N.R.
European Prospective Investigation into Cancer and Nutrition Physical Activity Questionnaire	1	1	1	3	1	1	1	1	N.R.	3/1

(EPIC PAQ)⁴¹

13-Item
Physical
Activity
Questionnaire

(13I-PAQ)⁴²

Questionnaire
d'Activité

Physique pour
les Personnes
Âgées

(QAPPA)⁴³

Incidental and
Planned
Exercise

Questionnaire
(IPEQ)⁴⁴

Physical
Activity
Questionnaire

for Elderly
Japanese

(PAQ-EJ)⁴⁵

The
Longitudinal
Ageing Study

Amsterdam
Physical
Activity

Questionnaire
(LAPAQ)⁴⁶

Nordic
Physical
Activity

1

1

2

1

NA

NA

NA

N.R.

NA

2/N.R.

1

4

2

1

1

NA

NA

1

2

4/4

1

1

2

1

NA

NA

NA

N.R.

NA

2/N.R.

1

1

3

3

NA

NA

NA

N.R.

NA

3/N.R.

1

1

1

3

NA

NA

NA

1

NA

3/1

1

1

1

3

1

NA

NA

N.R.

N.R.

3/N.R.

Questionnaire (NPAQ- short) ⁴⁷										
Self-report physical activity questionnaire (SPAQ) ⁴⁸	1	1	1	3	NA	NA	NA	N.R.	NA	3/N.R.
Transport and Physical Activity Questionnaire (TPAQ) ⁴⁹	1	1	2	1	1	NA	NA	2	N.R.	2/2
General Practice Physical Activity Questionnaire (GPPAQ) ⁵⁰	1	4	1	NA	1	1	1	N.R.	2	4/4
Sedentary Behaviour										
International Physical Activity Questionnaire - Sedentary Behaviour (IPAQ-SB) ⁵¹	1	1	1	3	1	NA	NA	N.R.	N.R.	3/N.R.
Australian Longitudinal Study on Women's Health - Sedentary Behaviour	1	1	1	1	NA	NA	NA	2	NA	1/2

Questions (ALSWH - SB Q) ⁵²										
Self-reported sitting and breaks from sitting in the workplace (SBSW) ⁵³	1	1	2	1	NA	NA	NA	N.R.	NA	2/N.R.
Workplace Sitting Breaks Questionnaire (SITBRQ) ⁵⁴	1	1	2	3	1	1	1	N.R.	2	3/2
Sedentary Behavior Questionnaire (SBQ) ⁵⁵	1	1	2	1	NA	NA	NA	N.R.	NA	2/N.R.
SED-GIH ⁵⁶	4	1	4	1	1	1	1	N.R.	N.R.	4/N.R.
Workforce Sitting Questionnaire (WSQ) ⁵⁷	1	1	1	1	NA	NA	NA	N.R.	NA	1/N.R.
Japanese- Language Self-reported Measures for Assessing Adults Domain- Specific Sedentary Time (JSRM - SB) ⁵⁸										
Longitudinal	1	1	1	1	NA	NA	NA	N.R.	NA	1/N.R.

Aging Study Amsterdam questionnaire (LASA) ⁵⁹										
SB question of the Yale Physical Activity Survey (YPAS - SB) ⁶⁰	1	1	1	1	1	NA	NA	N.R.	NA	1/N.R.
Community Health Activities Model Program for Seniors SB questions (CHAMPS - SB) ⁶⁰	1	1	1	1	NA	NA	NA	N.R.	NA	1/N.R.
Cancer Prevention Study-3 Sedentary Time Survey (CPS-3 ST) ⁶¹	1	1	1	3	NA	NA	NA	N.R.	NA	3/N.R.
Sleep										
BRFSS sleep questions (BRFSS Sleep) ⁶²	1	1	3	4	NA	NA	NA	N.R.	NA	4/N.R.
Physical Activity + Sedentary Behaviour										
Kaiser Physical Activity Survey (KPAS) ⁶³	1	1	1	1	NA	NA	NA	N.R.	NA	1/N.R.

Sedentary, Transportation and Activity Questionnaire (STAQ) ⁶⁴	1	1	1	1	NA	NA	NA	2	NA	1/2
International Physical Activity Questionnaire (IPAQ) ⁶⁵	1	1	2	3	4	NA	NA	N.R.	2	4/2
Australian Women's Activity Survey (AWAS) ⁶⁶	1	1	1	1	NA	NA	NA	2	NA	1/2
Workers' sitting- and walking-time questionnaire Time Method (WSWQ- t-method) ⁶⁷	1	1	1	1	1	NA	NA	N.R.	N.R.	1/N.R.
The Physical Activity Scale for the Elderly (PASE) ⁶⁸	1	4	2	3	NA	NA	NA	N.R.	NA	4/N.R.
Community Health Activities Model Program for Seniors physical activity self-report questionnaire	1	4	1	1	NA	NA	NA	N.R.	NA	4/N.R.

+ transport
items
(CHAMPS+transport)⁶⁹

Community
Healthy
Activities
Model
Program for
Seniors
(CHAMPS)⁷⁰

1	4	1	1	NA	NA	NA	N.R.	NA	4/N.R.

Modified
Version of the
MONICA
Optional Study
on Physical
Activity
Questionnaire
(Modified
MOSPA-Q)⁷¹

1	1	4	1	NA	NA	NA	N.R.	NA	4/N.R.

Occupational
Sitting and
Physical
Activity
Questionnaire
(OSPAQ)^{71,72}

1	1	4	1	NA	NA	NA	N.R.	NA	4/N.R.

Rapid
Assessment
Disuse Index
(RADI)⁷³

1	1	2	1	NA	NA	NA	N.R.	NA	2/N.R.

Global
Physical
Activity
Questionnaire
(GPAQ)⁷⁴

1	3	1	1	NA	NA	NA	N.R.	NA	3/N.R.

Sedentary Behaviour + Sleep										
SIT-Q ⁷⁵	1	1	1	1	1	1	1	1	1	1/1
Physical Activity + Sedentary Behaviour + Sleep										
Physical Activity Questionnaire (PAQ) ⁷⁶	2	1	2	3	NA	NA	NA	N.R.	NA	3/N.R.
Athens Physical Activity Questionnaire (APAQ) ⁷⁷	1	1	2	1	NA	NA	NA	2	NA	2/2
Sedentary Time and Activity Reporting Questionnaire (STAR-Q) ⁷⁸	1	1	1	1	NA	NA	NA	N.R.	NA	1/N.R.
Question 8 of the Paffenbarger Physical Activity Questionnaire (Q 8 PPAQ) ⁷⁹	1	1	1	1	NA	NA	NA	1	NA	1/1
EPIC-Norfolk Physical Activity Questionnaire (EPAQ2) ⁸⁰	1	1	1	3	1	1	NA	N.R.	4	3/4
Workers' sitting- and walking-time	1	1	1	1	1	NA	NA	N.R.	N.R.	1/N.R.

questionnaire
Percentage
Method
(WSWQ - p-
method)⁶⁷

New
Questionnaire
on Physical
Activity
(NQPA)⁸¹

Web-Based
Physical
Activity
Questionnaire
(Active-Q)⁸¹

Flemish
Physical
Activity
Computerized
Questionnaire
(FPACQ)⁸³

1	1	2	3	NA	NA	NA	2	NA	3/2
1	1	1	1	NA	NA	NA	N.R.	NA	1/N.R.
1	1	1	1	NA	NA	NA	2	NA	1/2

Ratings: 1= Very low Risk of Bias; 2= Low Risk of Bias; 3= Medium Risk of Bias; 4= High Risk of Bias. Abbreviations: NA = Not Applicable; N.R.= Not Reported

* According to COSMIN guidelines, overall quality rating is based on "worst counts method".

Tabela 7. Risk of Bias of Convergent Validity

Questionnaire (Convergent measure)	Design Requirements		Statistical Methods	Overall Rating*
	Clarity on the comparator instrument(s) measure(s)?	Measurement properties of the comparator instrument(s) are sufficient?	Were design and statistical methods adequate for the hypotheses to be tested?	
Physical Activity				
Nord-Trøndelag Health Study PA Questionnaire (HUNT 1) ³⁰ (IPAQ)	1	1	1	1
Nord-Trøndelag Health Study PA Questionnaire (HUNT 1) ³⁰ (VO2max)	1	1	1	1
Past Year Total Physical Activity Questionnaire (PYTPAQ) ³¹ (7-day PA log)	1	1	1	1
Physical Activity Assessment Tool (PAAT) ³² (IPAQ)	1	1	1	1
Minnesota Leisure Time Physical Activity Questionnaire (Minnesota LTPA Q) ³³ (4 wk history)	1	1	1	1
Minnesota Leisure Time Physical Activity Questionnaire (Minnesota LTPA Q) ³³ (VO2max)	1	1	1	1

Single Item Physical Activity Measure (SI PA M) ³⁴ (GPAQ)	1	1	2	2
Single Item Physical Activity Measure (SI PA M) ³⁴ (APS)	1	1	2	2
Godin Questionnaire (Godin Q) ³³ (4 wk history)	1	1	1	1
Godin Questionnaire (Godin Q) ³³ (VO2max)	1	1	1	1
CARDIA Physical Activity History (CARDIA) ³³ (4 wk history)	1	1	1	1
CARDIA Physical Activity History (CARDIA) ³³ (VO2max)	1	1	1	1
Minnesota Heart Health Program Questionnaire (MHHP Q) ³³ (4 wk history)	1	1	1	1
Minnesota Heart Health Program Questionnaire (MHHP Q) ³³ (VO2max)	1	1	1	1
Modified Historical Leisure Activity Questionnaire (MHLAQ) ³⁵ (PA LOG)	1	1	1	1
Modified version Active Australia Survey 1(MV – AAS1) ³⁶	NA	NA	NA	NA
(MV – AAS2)(Fjeldsoe et al., 2013)	NA	NA	NA	NA
Adapt AAS(Timperio et al., 2003)	NA	NA	NA	NA
IPAQ-WS(van der Ploeg et al., 2010)	NA	NA	NA	NA
SQUASH(Wendel-Vos et al., 2003)	NA	NA	NA	NA

European Prospective Investigation into Cancer and Nutrition Physical Activity Questionnaire (EPIC PAQ) ⁴¹ (FriedeN.R.eich LTPAQ)	1	1	1	1
13-Item Physical Activity Questionnaire (13I-PAQ) ⁴² (Body fat)	1	1	2	2
13-Item Physical Activity Questionnaire (13I-PAQ) ⁴² (VO2max)	1	1	2	2
13-Item Physical Activity Questionnaire (13I-PAQ) ⁴² (Flexibility)	1	1	2	2
Questionnaire d'Activité Physique pour les Personnes Âgées (QAPPA) ⁴³ (Satisfaction with body functioning)	1	4	2	4
Questionnaire d'Activité Physique pour les Personnes Âgées (QAPPA) ⁴³ (Decline in physical function)	1	4	2	4
Questionnaire d'Activité Physique pour les Personnes Âgées (QAPPA) ⁴³ (Age)	1	4	2	4
Incidental and Planned Exercise Questionnaire (IPEQ) ⁴⁴ (IPEQ-3 months v IPEQ-Week)	1	4	2	4
Incidental and Planned Exercise Questionnaire (IPEQ) ⁴⁴ (WHODAS)	1	4	2	4
Incidental and Planned Exercise Questionnaire	1	4	2	4

(IPEQ) ⁴⁴ (Time up-and-go)				
Incidental and Planned Exercise Questionnaire (IPEQ) ⁴⁴ (Age)	1	4	2	4
Physical Activity Questionnaire for Elderly Japanese (PAQ-EJ) ⁴⁵	NA	NA	NA	NA
The Longitudinal Ageing Study Amsterdam Physical Activity Questionnaire (LAPAQ) ⁴⁶	NA	NA	NA	NA
Nordic Physical Activity Questionnaire (NPAQ-short) ⁴⁷	NA	NA	NA	NA
Self-report physical activity questionnaire (SPAQ) ⁴⁸	NA	NA	NA	NA
Transport and Physical Activity Questionnaire (TPAQ) ⁴⁹	NA	NA	NA	NA
General Practice Physical Activity Questionnaire (GPPAQ) ⁵⁰	NA	NA	NA	NA
Sedentary Behaviour				
International Physical Activity Questionnaire - Sedentary Behavior (IPAQ-SB) ⁵¹	NA	NA	NA	NA
Australian Longitudinal Study on Women's Health - Sedentary Behavior Questions (ALSWH - SB Q) ⁵² (7-d behavior log)	1	1	1	1
Self-reported sitting and breaks from sitting in the workplace (SBSW) ⁵³	NA	NA	NA	NA

Workplace Sitting Breaks Questionnaire (SITBRQ) ⁵⁴	NA	NA	NA	NA
Sedentary Behavior Questionnaire (SBQ) ⁵⁵	1	1	1	1
SED-GIH ⁵⁶	NA	NA	NA	NA
Workforce Sitting Questionnaire (WSQ) ⁵⁷	NA	NA	NA	NA
Japanese-Language Self-reported Measures for Assessing Adults Domain-Specific Sedentary Time (JSRM - SB) ⁵⁸	NA	NA	NA	NA
Longitudinal Aging Study Amsterdam questionnaire (LASA) ⁵⁹	NA	NA	NA	NA
SB question of the Yale Physical Activity Survey (YPAS - SB) ⁶⁰	NA	NA	NA	NA
Community Health Activities Model Program for Seniors SB questions (CHAMPS-SB) ⁶⁰	NA	NA	NA	NA
Cancer Prevention Study-3 Sedentary Time Survey (CPS-3 sitting time) ⁶¹	NA	NA	NA	NA
Sleep				
BRFSS sleep questions (BRFSS Sleep) ⁶² (Theorized question)	1	4	4	4
Physical Activity + Sedentary Behaviour				
Kaiser Physical Activity Survey (KPAS) ⁶³ (PA record)	1	1	1	1
Sedentary, Transportation and	1	1	1	1

Activity Questionnaire (STAQ) ⁶⁴ (Contextualized logbook)				
International Physical Activity Questionnaire (IPAQ) ⁶⁵ (IPAQ Short forms)	1	1	1	1
Australian Women's Activity Survey (AWAS) ⁶⁶	NA	NA	NA	NA
Workers' sitting- and walking- time questionnaire Time Method (WSWQ- t-method) ⁶⁷	NA	NA	NA	NA
The Physical Activity Scale for the Elderly (PASE) ⁶⁸ (Perceived health)	1	1	1	1
The Physical Activity Scale for the Elderly (PASE) ⁶⁸ (Sick Impact Profile)	1	1	1	1
The Physical Activity Scale for the Elderly (PASE) ⁶⁸ (Grip Strength)	1	1	1	1
The Physical Activity Scale for the Elderly (PASE) ⁶⁸ (Balance)	1	1	1	1
Community Health Activities Model Program for Seniors physical activity self-report questionnaire + transport items (CHAMPS+transport) ⁶⁹	NA	NA	NA	NA
Community Healthy Activities Model Program for Seniors (CHAMPS) ⁷⁰ (6-Min Walk)	1	1	1	1
Community Healthy Activities Model Program for Seniors (CHAMPS) ⁷⁰ (Self-Reported Physical Functioning)	1	1	1	1

Modified Version of the MONICA Optional Study on Physical Activity Questionnaire (Modified MOSPA-Q) ⁷¹	NA	NA	NA	NA
Occupational Sitting and Physical Activity Questionnaire (OSPAQ) ^{71,72}	NA	NA	NA	NA
Occupational Sitting and Physical Activity Questionnaire (OSPAQ) ^{71,72}	1	1	1	1
Rapid Assessment Disuse Index (RADI) ⁷³	NA	NA	NA	NA
Global Physical Activity Questionnaire (GPAQ) ⁷⁴ (IPAQ)	1	1	1	1
Sedentary Behaviour + Sleep				
SIT-Q ⁷⁵	1	1	1	1
Physical Activity + Sedentary Behaviour + Sleep				
Physical Activity Questionnaire (PAQ) ⁷⁶ (Self-administered structured 7-day PA diary)	1	1	1	1
Athens Physical Activity Questionnaire (APAQ) ⁷⁷	NA	NA	NA	NA
Sedentary Time and Activity Reporting Questionnaire (STAR-Q) ⁷⁸	1	1	1	1
Question 8 of the Paffenbarger Physical Activity Questionnaire (Q 8 PPAQ) ⁷⁹	NA	NA	NA	NA
EPIC-Norfolk Physical Activity Questionnaire (EPAQ2) ⁸⁰ (VO2max)	1	1	1	1
Workers' sitting- and walking-	NA	NA	NA	NA

time

questionnaire Percentage
Method (WSWQ - p-method)⁶⁷

New Questionnaire on Physical
Activity (NQPA)⁸¹ (PA Diary)

1	1	1	1

Web-Based Physical Activity
Questionnaire (Active-Q)⁸²

NA	NA	NA	NA

Flemish Physical Activity
Computerized Questionnaire
(FPACQ)⁸³

NA	NA	NA	NA

Ratings: 1= Very low Risk of Bias; 2= Low Risk of Bias; 3= Medium Risk of Bias; 4= High Risk of Bias. Abbreviations: NA = Not Applicable.

* According to Cosmin, overall quality rating is based on "worst counts method".

Tabela S8. Risk of Bias of Responsiveness

	Design Requirements	Statistical Methods	Other	
Questionnaire	Adequate description of important characteristics of the subgroups provided?	Were design and statistical methods adequate for the hypotheses to be tested?	Any other important flaws?	Overall Rating
Community Healthy Activities Model Program for Seniors (CHAMPS) ⁷⁰	3	1		3

Ratings: 1= Very low Risk of Bias; 2= Low Risk of Bias; 3= Medium Risk of Bias; 4= High Risk of Bias

* According to Cosmin, overall quality rating is based on "worst counts method".

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4.2.8. Supplementary work 8 – PRISMA Checklist

Tabela S9. PRISMA Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	First page
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Abstract
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Line 59 to to 105
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Line 105 to 108
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Line 112 to 133
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Line 136 to 138
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Line 139 to 144 and appendix 1
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Line 147 to 51
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Line 153 to 162
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Appendix 2
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources).	Appendix 2

Section and Topic	Item #	Checklist item	Location where item is reported
		Describe any assumptions made about any missing or unclear information.	
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Line 167 to 181
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Line 185 to 229
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Line 232 and 233
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Not applicable
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Line 232 and 233
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Line 232 and 233
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Not applicable
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Not applicable
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Not applicable
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Not applicable
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Line 238 to 241 and flowchart
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Flowchart
Study characteristics	17	Cite each included study and present its characteristics.	Table 2 and Appendix 4 and 5
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Line 380 to 390 and

Section and Topic	Item #	Checklist item	Location where item is reported
			appendix 7
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Appendix 4 and 5
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Line 238 to 390; table 2 and 4; and appendix 3, 4, 5, and 6
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Not applicable
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Not applicable
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Not applicable
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Not applicable
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Not applicable
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Line 395 to 464
	23b	Discuss any limitations of the evidence included in the review.	Line 467 to 477
	23c	Discuss any limitations of the review processes used.	Line 467 to 477
	23d	Discuss implications of the results for practice, policy, and future research.	Line 447 to 464
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Line 490 to 492
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Line 490 to

Section and Topic	Item #	Checklist item	Location where item is reported
			492
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Not applicable
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Line 499 to 506
Competing interests	26	Declare any competing interests of review authors.	Line 498
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Line 496 and 497

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: <http://www.prisma-statement.org/>

Chapter 5

5.1. Study 2 (Paper II) – Questionnaires Measuring 24-Hour Movement Behaviours in Childhood and Adolescence: Content Description and Measurement Properties - A Systematic Review

(Published)

Questionnaires Measuring 24-Hour Movement Behaviors in Childhood and Adolescence: Content Description and Measurement Properties—A Systematic Review

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Background: We aim to systematically review the literature on measurement properties of self- and proxy-reported questionnaires measuring 24-hour movement behaviors in children and adolescents. **Methods:** PubMed, PsycINFO, SPORTDiscus, and EMBASE were searched until June 2021. Studies were included if the sample size for validity studies had 50 participants (minimum) and included, at least, both validity and test-retest reliability results of questionnaires. The review followed an adaptation of the Consensus-based Standards for the selection of health Measurement INstruments guidelines, to evaluate the quality of measurements properties of the questionnaires (content, convergent and criterion validity, reliability, measurement error, and responsiveness), as well as the risk of bias of each measurement property. **Results:** This review included 29 studies, describing 37 questionnaires. Sixty-eight percent showed “adequate” content validity. None of the questionnaires showed overall “adequate” criterion validity, and the risk of bias was “very low” for 92%. One questionnaire showed “adequate” convergent validity, and 73% of the studies were classified with a “high risk of bias.” Seven questionnaires showed “adequate” reliability, and 27.3% of the studies were rated with a “very low risk of bias.” None of the questionnaires showed “adequate” criterion validity and reliability, simultaneously. **Conclusions:** Existing questionnaires have insufficient measurement properties, and none considered the 24-hour movement behavior paradigm. These results highlight the need for better questionnaires of movement behavior combinations, to improve the monitoring and surveillance systems of 24-hour movement behaviors in this population.

Keywords: monitoring and surveillance, children and adolescents, sleep, sedentary behavior, physical activity

The health-related associations of appropriate levels of movement behaviors (ie, physical activity [PA], sedentary behavior [SB], and sleep, across a 24-h period^{1–3}) in children and adolescents have been described and led to an increased interest by public health authorities in this new 24-hour movement paradigm. As such, some countries have developed^{4–6} 24-hour movement guidelines for young children, children, and adolescents, and the World Health Organization has also developed PA, SB, and sleep guidelines for young children.⁷ These new guidelines, incorporating sleep, SB, and PA, demand adaptation of the current monitoring and surveillance instruments to accurately assess movement behaviors in an integrated way and to assess compliance with such guidelines. The

accurate measurement of movement behavior levels and patterns is paramount to better understand the health-related associations of these behaviors, determining its correlates and predictors, monitoring 24-hour movement patterns and levels, and to evaluate the effectiveness of interventions. Although the accurate assessment of movement behaviors is important for research, policy, and practice, measuring them is a challenging and complex procedure.

There are many methods to assess movement behaviors in children and adolescents. While accelerometers are accurate instruments to assess movement behaviors,^{8–15} in large-scale epidemiological studies and clinical contexts, questionnaires are preferred due to their practicality, simplicity, and affordability.^{8,16–19} Accelerometer-derived results are dependent on researcher decisions on data reduction, the potential use of algorithms or imputation techniques, and are labour-intensive.^{16,20} On the other hand, questionnaires can collect specific contextual details (eg, domains) that objective measures are unable to.^{8,16,21} However, assessing movement behaviors with questionnaires has several limitations, such as measurement errors and reporting bias, given that questionnaires’ responses are often influenced by social desirability, language interpretation, complexity of the questionnaire, age, and season.^{8,18,19,22} Additionally, if the questionnaires’ development methods and the measurement properties are poor or unclear, the risk of misclassification, bias, and inaccurate results is high.²³

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Assessing children and adolescents' movement behaviors with questionnaires can be even more challenging than in adults. Indeed, comparing to adults, children and adolescents have greater difficulties in reporting past movement behaviors due to their unstable patterns^{24,25} and cognitive differences, particularly in the ability to think abstractly and perform detailed recall,¹⁷ leading to an overestimation of PA's intensity and volume.²⁶ It is also known that the younger the children are, the lower their ability to recall and report movement behaviors, which is often solved via proxy-report by parents or caregivers.^{27–30}

Recently, 3 systematic reviews on measurement properties of PA questionnaires^{31–33} reported several methodological limitations and weak measurement properties, together with a lack of studies reporting measurement error and content validity. Concerning SB questionnaires, a systematic review⁸ concluded that, for most questionnaires, validity and reliability evidence was of low quality, and there was a wide methodological diversity between studies. More recently, 2 systematic reviews^{32,34} also reported no conclusive recommendation about the best available questionnaire to measure SB in children and adolescents. Regarding sleep questionnaires for children and adolescents, research has shown that the existing ones often do not report psychometric properties,³⁵ and many typically focus on assessing sleep disorders.^{19,35,36} A meta-analysis⁹ on sleep duration questionnaires reported that most studies used accelerometers as the criterion measure for validation, and these are likely to have acceptable reliability. However, current evidence does not allow for identification of the best questionnaire to evaluate these movement behaviors in an integrated fashion, under the new 24-hour movement paradigm.

Considering the new 24-hour movement behavior paradigm, examining the combination of behaviors composing a day seems vital to better understand the complexity of the interactions between these behaviors and their health effects. The existing reviews on questionnaires' measurement properties to assess sleep, SB, and PA were focused on questionnaires assessing each behavior in isolation, without considering questionnaires assessing more than one behavior. Therefore, there is a tangible need to analyze the questionnaires measuring each movement behavior individually, as well as the questionnaires that measure movement behavior combination over 24 hours. Such scrutiny will increase our understanding regarding validity and reliability of existing questionnaires measuring movement behaviors as time-dependent behaviors, with the potential to help researchers and policy makers interested in assessing each movement behavior individually or any combination of movement behaviors, to choose the instrument with the best trade-off between measurement properties quality, population, and study purpose, in children and adolescents. In this sense, we aim to systematically review the literature on measurement properties of self- and proxy-reported questionnaires assessing all movement behaviors, individually or in combination, in children and adolescents.

Methods

Consensus-based Standards for the selection of health Measurement INstruments (COSMIN) guidelines for systematic reviews of patient-reported outcome measures³⁷ were adapted for this review. These are in accordance with the Cochrane Handbook for systematic reviews of interventions³⁸ and the PRISMA statement for reporting systematic reviews and meta-analyses.³⁹ The adaptation of the COSMIN guidelines consisted in using only the guidelines for each measurement property that suited the structure and

response options of the included questionnaires. For example, the COSMIN foresees the evaluation of Patient-Reported Outcome Measures, created in a reflective model (with scales and subscales), and structural and internal validity may be performed, which was not the case for the questionnaires included; therefore, these types of evaluation were not carried out. This review's information is presented slightly different than that proposed by COSMIN's to accommodate the specificities of the included questionnaires. Population, Intervention, Control, Outcome (PICO) used in this study can be found in [Supplementary Material S1](#) (available online).

Eligibility Criteria

The inclusion criteria were the following: (1) children and adolescents (younger than 17.9 y); (2) minimum sample size of 50 participants for validity studies⁴⁰; (3) studies reporting validity and test-retest reliability results^{37,41} of self-reported or proxy-reported questionnaires that were developed specifically to measure sleep, SB, or PA, or their combination; and (4) studies written in English, Spanish, French, Portuguese, German, Italian, or Chinese.

The exclusion criteria were the following: (1) studies using doubly labeled water as criterion measure, given that it assesses total energy expenditure and not only PA energy expenditure^{41,42}; (2) studies evaluating questionnaires aimed solely at predicting or detecting a given health condition, designed for specific populations (eg, chronic, autoimmune and infectious diseases, sleep disorders, athletes, pregnant women) or focused only on lifetime sleep, SB, and/or PA; (3) studies reporting measurement properties of questionnaires not designed to validate an original questionnaire (eg, reported linguistic validation); (4) studies reporting sleep, SB, and/or PA measurement properties of logs, diaries, or interviews; and (5) grey literature (eg, thesis, book chapters), abstracts, reviews, meta-analyses, commentaries, cost-effectiveness studies, and pilot studies.

Information Sources and Search Strategy

We systematically searched 4 electronic databases: PubMed, PsycINFO, SPORTDiscus, and EMBASE (June 2021), without temporal limits of search. Additional studies were identified by manually searching references from the retrieved papers and authors personal libraries, to ensure no relevant studies were overlooked.

The electronic databases were searched for variations of the terms “children,” “adolescents,” “sleep,” “sedentary behavior,” “physical activity,” “movement behaviors,” “questionnaire,” and “measurement properties” (for a detailed search strategy see [Supplementary Material S2](#) [available online]). The search terms were adapted for each specific electronic database to ensure the quality of the systematic searching.

Screening

Three authors independently selected potentially relevant studies based on titles, abstracts, and full texts. Disagreements were discussed with a fourth author. The study selection procedure was conducted via the Central Access Database for Impact Assessment of Crop Genetic Improvement Technologies (CADIMA) software.⁴³

Data Extraction

A standardized data extraction form was developed by 2 authors, to gather relevant information from the included studies (see

Supplementary Material S3 [available online]) regarding the characteristics of the questionnaire, the methods, and measurement properties' results. Data were extracted by 3 authors and checked by a fourth author.

Given this review's characteristics, data extraction on content and measurement properties was based on COSMIN guidelines,³⁷ the Taxonomy of Self-reported Sedentary Behavior Tools framework,⁴⁴ and the Quality Assessment of Physical Activity Questionnaire Checklist.⁴¹ The Edinburgh Framework⁴⁵ for validity and reliability in PA and SB measurement was also considered. When needed, adaptations were made to integrate sleep as a movement behavior. The data were collected independently by 6 authors and disagreements were resolved by discussion with another author. The definitions for the outcome variables used in this systematic review are explained below.

Studies' Risk of Bias Assessment

The Risk of Bias checklist developed by COSMIN³⁷ was used to assess the methodological quality of the included studies. This checklist has a 4-point scale (ie, "very good," "adequate," "doubtful," or "inadequate") and contains items on criterion validity, reliability, measurement error, and responsiveness. For each measurement property, different design requirements and statistical methods were rated based on COSMIN standards,³⁷ and therefore, the overall rating was determined based on "the worst score counts" method.

The criteria for each item can be found in COSMIN guidelines.³⁷ For reliability, in line with previous work,⁴⁶ we defined an "adequate" time interval between test and retest as follows: >1 day and ≤3 months for questionnaires recalling a usual week/month, >1 day and ≤2 weeks for questionnaires recalling the previous week, >1 day and ≤1 week for questionnaires recalling the previous day, and >1 day and ≤1 year for questionnaires recalling the previous year. Data were independently collected by 5 authors and disagreements were discussed with another author.

Effect Measures

Quality of Measurement Properties. To appraise the quality of measurement properties' results, COSMIN guidelines³⁷ were followed. All measurement properties were rated against quality criteria for good measurement properties,⁴⁷ and each result was rated as "inadequate" (–), "doubtful" (?), or "adequate" (+). Studies were classified as "doubtful" when its design or method was not well reported.

For the overall rating of the studies' quality, if 75% of the results per study were "adequate," the overall rating was also considered "adequate."

Criterion Validity. Studies were classified as having "adequate criterion validity" (ie, the extent of the correlation between a measure and another already considered as being a criterion or gold standard) when the results for correlations between the questionnaire and the criterion instrument (ie, accelerometer, pedometer for walking measures) were ≥0.70 (with a statistically significant P value < .05). Although there is no gold standard to measure all movement behaviors, the accelerometer was considered an appropriate criterion measure because it is an instrument able to accurately measure all movement behaviors, and it is widely used as a criterion comparison measure in validation studies of movement behaviors questionnaires, particularly in children and adolescents.⁴⁸

Convergent Validity. For convergent validity (ie, the extent of the agreement with another [noncriterion] measure that should assess the same behavior parameter based on face and content validity), a study was rated with "adequate convergent validity" if the correlation between the questionnaire and the other assessments related to the behavior in question (eg, between self-reported PA intensity and objectively measured VO_2max) was $\geq .5$ and P value < .05. Equally, a study was rated with "adequate convergent validity" if the correlations between a similar self-reported instrument and the questionnaire were $\geq .7$ and P value < .05.

Reliability. For reliability test–retest (ie, the extent to which test scores are consistent from one test administration to the next, keeping the same conditions, such as researcher, timing, preparation), intraclass correlation coefficients (ICCs) for continuous variables or weighted *kappas* for categorical variables $\geq .70$ were considered "adequate"; given that Pearson or Spearman correlation coefficients do not take into account systematic errors,⁴⁹ only correlations $\geq .80$ were rated "adequate."⁴²

Measurement Error. Measurement error (eg, how close the scores on repeated administrations are), expressed in the unit of the questionnaire (ie, limits of agreement, SEM, smallest detectable change), was considered "adequate" when the smallest detectable change or limits of agreement were smaller than minimal important change, and "doubtful" when minimal important change was not defined by the study's authors. Responsiveness (ie, the ability of an instrument to detect change over time in the construct to be measured; refers to the validity of a change score) was considered "adequate" when the result was in accordance with the hypothesis or if the area under the curve was ≥ 0.70 , and "doubtful" when no hypothesis was defined.

Evaluation of Content Validity. We applied a subjective reviewers' rating to assess the content validity of all included questionnaires, as recommended by COSMIN.³⁷ In this evaluation, all questionnaires' items were rated as "adequate" (+) or "inadequate" (–), considering: (1) items' relevancy for the construct, population, and context of use (ie, the item had to be directly related to the construct or behavior evaluated); (2) response options and recall period appropriateness for construct, population, and context of use (ie, closed response options were considered inappropriate because they do not capture the movement *continuum*; the recall period and context had to be clearly stated); (3) comprehensiveness of the construct, population, and context of the use of interest (ie, key aspects, such as duration or intensity related to the construct or behavior had to be clearly stated); and (4) language appropriateness of the response options and items (ie, clear and simple language).

When the questionnaire form was not embedded in the article, we searched it online. If the questionnaires were not found online, authors were contacted, requesting the questionnaires, at least twice, separated by a minimum of 2 weeks. If it was not possible to access the questionnaire (online unavailability or authors lack of response), we rated it as "cannot be determined."

Synthesis Methods

Given the specificity of this review and the diversity of the included studies in terms of methodology used and results reported, a meta-analysis was not possible. As such, we chose to present a narrative synthesis of the results, *per* property measurement and age group and organized it in the respective tables (as presented in the "Results" section).

Results

Search Results

The search yielded 9382 studies after removing duplicates. Six studies were added after a manual search. After screening titles and abstracts, 70 full texts were selected and 29 were included, describing 37 questionnaires. The reasons for full texts' exclusion are described in Figure 1.

Synthesis Results

Content Description. The characteristics of the included questionnaires are presented in Table 1. Twenty questionnaires measured PA (2 in children,^{30,50} 16 in adolescents,^{30,50–61} and 2 in both^{62,63}); 6 measured SB (1 in children,⁶⁴ 4 in adolescents^{64–67} and, 1 in both⁶⁸); and 1 measured sleep duration in children and adolescents.⁶⁹ Eight questionnaires measured behaviors' combinations, namely PA and SB (1 in children,⁷⁰ 3 in adolescents^{55,71,72} and, 4 in both^{73–76}), and 2 measured sleep, SB, and PA in children and adolescents.⁷⁷ Out of the 37 questionnaires included, 7 were proxy-reported.^{30,50,64,69,76,77} There were no questionnaires (proxy reports) designed for babies and toddlers (<3 y of age).

Regarding PA questionnaires,^{30,50,51,53–63} 70% assessed multi-domain PAs, with leisure-time PA (out of school or after school) being the most frequent domain assessed (measured in 12/20 questionnaires). The most prevalent response method was the continuous method (75%; 15/20), focusing on different metrics (eg, min/d; times/wk). The most frequent measurement units (75%; 15/20) were temporal (ie, min/wk/d; h/d; times/wk). Most questionnaires assessed multiple scores (90%; 18/20). Recall periods varied from past week (40%; 8/20), usual week (30%, 6/20), past year (20%, 4/20), usual day (5%; 1/20), to past 3 days (10%, 2/20). The assessment period was specified in 40% of the PA questionnaires (8/20). The number of items included in the PA questionnaires ranged from 1 to 84.

All SB questionnaires^{64–68} assessed its multidomains, with screen time being present in all included questionnaires. Out of the 6 questionnaires, 3^{64,67} used the continuous response method, with the remaining using rating scales.^{65,66,68} Time-focused measurement units were used in all questionnaires (ie, min/h/d/wk). All questionnaires assessed multiple scores, depending on the domain evaluated. Past week was the most frequent recall period (67%; 4/6), and all questionnaires specified the assessment period. The number of items included in the questionnaires ranged from 5 to 24.

One questionnaire assessed sleep duration,⁶⁹ with 12 questions. The response method was continuous; the measurement unit was time (hours and minutes) for bed and waking times, and for lights turned off, minutes to falling asleep and minutes per nap. The score was the sleep period. The recall period was a typical day, with assessment periods for weekdays and weekend days.

The questionnaires combining PA and SB,^{55,70–76} mostly assessed the behaviors through multidomain (88%; 7/8), with leisure PA and screen-time SB domains being the most predominant (63%; 5/8). Continuous method was the most prevalent response method (63%, 5/8); and all questionnaires used temporal metrics (eg, minutes per day). The measurement units were focused on temporal metrics in all but 3 questionnaires^{70,73,74} which determined METs. Most questionnaires assessed PA and SB through multiple scores (88%; 7/8). The recall periods were divided into usual day per week (50%; 4/8) and/or past day per week (63%; 5/8). The assessment period was specified in 63% of the questionnaires (5/8). The number of items included in the questionnaires ranged from 2 to 45.

One questionnaire was organized in a list of activities⁷⁶ and 2 were segmented by day format.^{72,73}

Two questionnaires assessed PA, SB, and sleep,⁷⁷ one proxy- and the other self-reported. The questionnaires were focused on light, moderate, and vigorous PA time, screen, and sitting time, and sleep duration. The response method was continuous (hours per day), the measurement unit was hours per day, and the questionnaire assessed multiple scores (3 for PA, 2 for SB, and 1 for sleep). The recall period was a typical day, and the assessment periods were on a school day and on a weekend day.

Among the included questionnaires, none were designed to assess the movement behaviors considering the 24-hour movement behavior paradigm.

Content Validity. Considering all questionnaires included, 55.3% showed “adequate” content validity. Regarding PA questionnaires, 5 were considered “inadequate” (4 in adolescents^{52,55,56,59} and 1 in children and adolescents⁶²). Seven questionnaires were not available (1 in children,³⁰ 5 in adolescents,^{30,53,60} and 1 in both⁶³); therefore, their content validity could not be determined. For SB, 3 questionnaires were rated with “inadequate” content validity (2 in adolescents^{65,66} and 1 in children and adolescents⁶⁸). The sleep questionnaire was rated with “adequate” content validity. For PA and SB, one questionnaire in children⁷⁰ was rated with “inadequate” content validity. For the combination of PA, SB, and sleep, the questionnaires were not available; therefore, their content validity could not be determined. The main reason for the content validity inadequacy was the response options not being considered adequate (ie, closed response, rating scales). Content validity results and its details are provided in [Supplementary Material S4](#) (available online).

Validity. Table 2 summarizes the results of questionnaires' validity. No questionnaire showed overall “adequate” criterion validity. The computer-based physical activity questionnaire⁶⁰ showed “adequate” convergent validity. The most frequently calculated coefficients were Pearson and Spearman correlations and ICCs coefficients. Limits of agreement were examined in 10.5% of the questionnaires (3/29) through Bland and Altman plots.

In PA questionnaires, the most frequently used criterion measure was the accelerometer (90%; 18/20). The strongest criterion validity was “Total PA” score from SAYCARE Physical Activity Questionnaire for adolescents⁵⁰ ($\rho = 0.88$), which was rated with “adequate” criterion validity. Convergent validity was measured in the Habitual Physical Activity Questionnaire,⁵² Health Behavior in Schoolchildren Physical Activity Questionnaire,⁵⁵ Adolescent Physical Activity Recall Questionnaire,⁵⁸ past year physical activity in adolescents,⁵⁹ and computer-based physical activity questionnaire,⁶⁰ with computer-based physical activity questionnaire being the only questionnaire showing “adequate” convergent validity against a 7-day PA log.⁶⁰

Regarding SB, no questionnaire exhibited overall “adequate” criterion or convergent validity. The accelerometer was the criterion measure in all questionnaires that assessed criterion validity. The Eating and Activity Questionnaire Trial—Sedentary Behavior questions⁶⁵ was the only questionnaire evaluated against a convergent measure (7-d log of television viewing and computer use). None of the scores from the questionnaire showed “adequate” criterion or convergent validity.

The only sleep questionnaire included⁶⁹ was evaluated against a criterion measure (accelerometer), and its validity was considered “inadequate.”

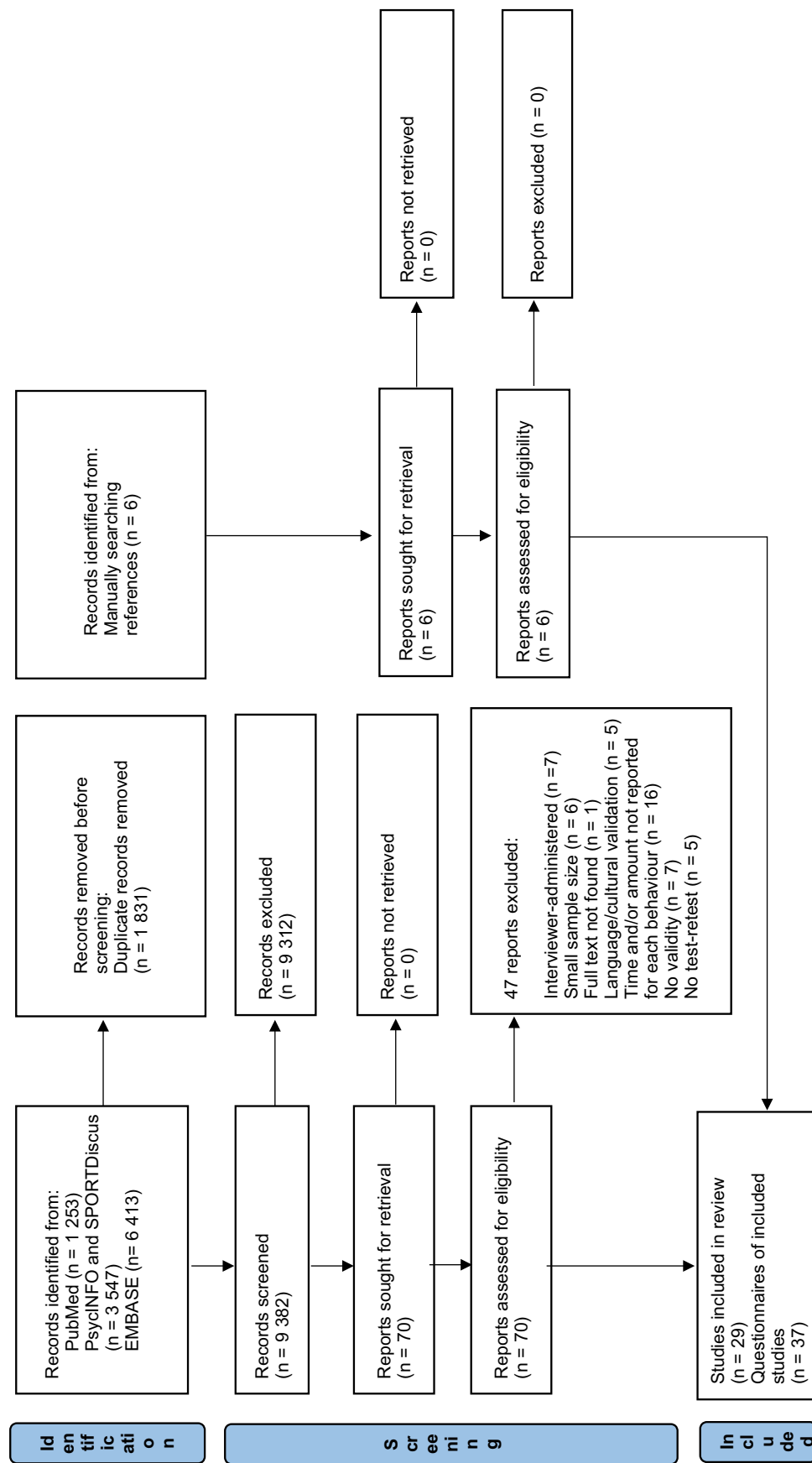


Figure 1 — Study selection process flowchart. n indicates number of studies.

Table 1 Content Characteristics of the Included Movement Behavior Questionnaires

Questionnaire	Age group, country	Mode of administration	Domains	Response method	Units of measurement	Scores	Recall period/assessment period	No. of items	Parameters
Physical activity CLASS— Proxy ³⁰	Children (5–6 y), Australia	Proxy-reported	Leisure; sports; total PA	Continuous: times/wk; min or h/d	min or h/d	Frequency MPA; frequency VPA; duration MPA; duration VPA intensity	Usual week-day and week-end day in a typical week	30 activities + 6	F; D; I; M
SAYCARE PA Q C ⁵⁰	Children (3–10 y), South America	Proxy-reported	School; leisure; transportation	Participate yes/no; if yes, continuous; frequency, duration, and intensity	min/d PA school; min/wk PA leisure; min/d PA commuting	PA at school; time spent PA leisure; PA commuting; MPA; VPA; total PA; guideline's compliance	Past week	47	F; D; I
O-O-S PAQ ⁵¹	Adolescents (11 y), Finland	Self-reported	Out of school (leisure and sports)	Rating scale: h/wk and times/wk (10 options)	min/d and times/wk	MVPA duration and MVPA frequency	Usual week during weekdays	2	F; D
HPAQ ⁵²	Adolescents (11–16 y), Brazil	Self-reported	Sports; transportation	Continuous: h/d; d/wk; mo/y	min/wk; min/y	Weekly PA score; yearly PA score	Past year	7–17	F; D; M
3DPAR ⁵³	Adolescents (11–14 y), United States	Self-reported	Before, during, after school	For each activity rate, its intensity across 4 categories	Number of 30-min blocks per intensity MVPA and VPA	MVPA; VPA	Past 3 d	?	F; D; I; M
YRBS ⁵⁴	Adolescents (12.7 [0.6] y), United States	Self-reported	Total PA by intensity	Continuous: min/d	min/d	Meeting guidelines	Past week in weekdays and weekend days	2	F; D; I
SAPAC ⁵³	Adolescents (11–14 y), United States	Self-reported	Before, during, after school	Checklist of responses (continuous: min/d)	min/d	MVPA; VPA	Past 3 d	?	F; D; I; M
HBSC PAQ ⁵⁵	Adolescents (13–18 y), Norway	Self-reported	Outside school	Rating scale	Categories: “Low activity” represents “one day a week or less” or “one hour a week or less”; “moderate activity” represents “2–3 days a week” or “2–3 hours a week”; “high activity” represents “four days a week or more” or “four hour a week or more”	Frequency; duration; frequency, 3 categories; duration, 3 categories	Usual week, outside school	2	F; D

(continued)

Table 1 (continued)

Questionnaire	Age group, country	Mode of administration	Domains	Response method	Units of measurement	Scores	Recall period/assessment period	No. of items	Parameters
MGLTEQ ⁵⁶	Adolescents (12–14 y), United States	Self-reported	Total PA by intensities	Continuous; d/wk	d/wk	Strenuous; moderate; mild	Usual week in summer and school time	3	F; I
OPAQ ⁵⁷	Adolescents (13–14 y), United Kingdom	Self-reported	Transport; physical education; school sport; after school sport	Continuous; d/wk, min/wk; list of activities	METS/wk	MPA; VPA; MVPA	Past week in weekdays and weekend days	8	F; D
APARQ ⁵⁸	Adolescents (13–15 y), Australia	Self-reported	Organized sports, games; nonorganized physical activities	List of activities; continuous; times/wk; h/time	METS	Energy expenditure (winter/summer, organized/nonorganized; inactive, adequate, vigorous)	Usual week during summer school terms and during winter school terms (excluding vacations)	12 (up to 84)	F; D; M
PYPAA ⁵⁹	Adolescents (12–16 y), United States	Self-reported	Leisure	Checklist; continuous; min/activity	MET-h/wk	Overall leisure physical activity in h/wk; MET-h/wk; VPA-h/wk	Past year	3 (up to 33)	F; D; M
cPAQ ⁶⁰	Adolescents (11–16 y), Malaysia	Self-reported	School; after-school; household	?	METS	LPA; MPA; VPA	Past year	71	F; D; I, M
S-I PA M ⁶¹	Adolescents (14.7 [0.5] y), Australia	Self-reported	MVPA	Continuous (number of d)	Number of d	MVPA	Past week	1	F; D; I
MPA and VPA S Q ⁵⁴	Adolescents (14.6 [1.4] y), United States	Self-reported	General MPA and VPA	Continuous (times/wk)	Number of d	30- and 60-min MPA and 20-min VPA (past week, typical week, and composite [average])	Past week and typical week	6	F; D; I
PACE + PAM ⁵⁴	Adolescents (12.1 [0.9] y), United States	Self-reported	General MVPA	Continuous (d/wk)	Number of d	MVPA	Past week and typical week	1 per recall period	F; D; I
SAYCARE PA Q A ⁵⁰	Adolescents (11–18 y), South America	Self-reported	School; leisure; transportation	Participate yes/no; if yes, continuous; frequency, duration, and intensity	min/d PA school; min/wk PA leisure; min/d PA commuting	PA at school; time spent PA leisure; PA commuting; MPA; VPA; total PA; guideline's compliance	Past week	47	F; D; I

(continued)

Table 1 (continued)

Questionnaire	Age group, country	Mode of administration	Domains	Response method	Units of measurement	Scores	Recall period/assessment period	No. of items	Parameters
CLASS-Proxy and self ⁶⁰	Adolescents (10–12 y), Australia	Proxy-reported and self-reported	Leisure; sports; total PA	Continuous; times/wk; min or h/d	min or h/d	Frequency MPA; frequency VPA; duration MPA; duration VPA intensity	Usual week-day and week-end day in a typical week	30 activities + 6	F; D; I; M
Fels PAQ ⁶²	Children and adolescents (7–19 y), United States	Self-reported	Sport; leisure; transportation; home	Rating scale: 1 (some-times) to 3 (regularly)	Points (reflecting intensity—METs—and frequency)	Total score; sport score; leisure score; work score	Past year	8	F; I
MoMo ⁶³	Children and adolescents (9–17 y), Germany	Self-reported	Total PA; sports; physical education	Continuous (times/wk; min/wk); rating scale for intensity (1 [shortness breath] to 3 [much sweating])	min/wk	General PA; PA in school; recreational sports outside clubs	Past week	28	F; D; I; M
Sedentary behavior SAYCARE SB Q C ⁶⁴	Children (3–10 y), Argentina, Peru, Colombia, Uruguay, Chile, and Brazil	Proxy-reported for children (parents)	TV; computer use; studying (adolescents); video games; passive play (children)	Continuous; min/d	min/wk	Total SB and achieving or not achieving the recommended limit of less than 120 min/d of SB	Past week in weekdays and weekend days	8	F; D; I; M
EAQT-SB ⁶⁵	Adolescents (11–15 y), United States	Self-reported	TV (and videos or playing video games) and computer use	Rating scale (1 [less than 1 h] to 6 [5 or more h])	h/d	Weekday TV (school period); weekend TV (school period); weekend TV (summer); weekday TV (summer); computer use; weekday average	Weekday; weekend in summer and school time	5	D; M
Helena SB Q ⁶⁶	Adolescents (12.5–17.5 y); Europe	Self-reported	TV viewing; computer games; console (video) games; internet for nonstudy reasons (hobbies); internet for study reasons; and study time (out of scholar schedule)	Rating scale (0 min to >4 h)	h/d	Weekly time and total score; weekend time	Usual day in week and weekend days	12	D

(continued)

Table 1 (continued)

Questionnaire	Age group, country	Mode of administration	Domains	Response method	Units of measurement	Scores	Recall period/assessment period	No. of items	Parameters
SIT-Q-7d ⁶⁷	Adolescents (15–16 y), The Netherlands	Self-reported	TV; computer; motorized transport; school; gaming	Checklist and continuous: min/activity	min/wk	Weekday ST; weekend day ST; average ST	Past week in week and weekend days	24	F; D; M
SAYCARE SB Q A ⁶⁴	Adolescents (11–18 y), Argentina, Peru, Colombia, Uruguay, Chile, and Brazil	Self-reported for adolescents	TV; computer use; studying (adolescents); video games; passive play (children)	Continuous: min/d	min/wk	Total SB and achieving or not achieving the recommended limit of less than 120 min/d of SB	Past week in weekdays and weekend days	8	F; D; I; M
YLSBQ ⁶⁸	Children and adolescents (8–18 y), Spain	Self-reported	Screen time (watching TV/videos; playing computer/video games and internet surfing); NSST-educational (doing homework/study with computer; doing homework/study without computer and reading for fun); NSST-social (sitting and talking; talking on the telephone; listening to music); NSST-others (sitting to rest; doing cognitive hobbies [ie, doing puzzles or playing cards] and traveling on motorized transport)	Rating scale (0 min to 5 h or 0 to 2 h 30 min)	Average min/d	Weekday ST; weekend ST	Past week in average week-day and week-end day	24	F; D
Sleep CCTQ ⁶⁹	Children and adolescents (4–11 y), United States	Proxy-reported	Night sleep period; naps	Continuous: h and min of waking up, going to bed, lights turned off; and min to falling asleep; min per nap	Sleep onset (calculated by h and min of waking up, going to bed, lights turned off; and min to falling asleep); h per nap	Sleep period	Typical week-day and week-end day	12	F

(continued)

Table 1 (continued)

Questionnaire	Age group, country	Mode of administration	Domains	Response method	Units of measurement	Scores	Recall period/assessment period	No. of items	Parameters
Physical activity + sedentary behavior GAQ ⁷⁰	Children (8–9 y), United States	Self-reported	Leisure; sedentary behaviors (TV; using computer; video games; on telephone)	Checklist and rating scale (3 points; none; less than 15 min; more than 15 min)	MET-weighted average was computed; score based on time spend on sedentary behavior	Total PA score; (weighted) MET values; GAQ summary score	Past day; usually day	27 for physical activity; 7 for sedentary behavior	F; D; M
ENERGY-C Q ⁷¹	Adolescents (10–12 y), Belgium, Greece, Hungary, The Netherlands, Norway, and Spain.	Self-reported	Transport; sports; computer use; TV; leisure	Continuous; d/wk; min/d; h/wk; h/d	d/wk; min/d; h/wk; h/d	Bike to school; walk to school; car to school; public transport to school; first sport; second sport; sport past day; computer use in free time in week and weekend days; past day TV; past day computer use	Past week and past day, in weekend and weekdays	15	F; D
IPAQ ⁵⁵	Adolescents (13–18 y), Norway	Self-reported	Leisure	Continuous; d/wk and min/d	d/wk and min/d	Sitting; LPA; MPA; VPA; walking	Usual or past week in week and weekend days	?	F; D
SHAPES physical activity questionnaire ⁷²	Adolescents (11–18 y), Canada	Self-reported	Sports; transportation; leisure physical activities; screen time	Continuous; time/d	min/wk	VPA; MPA; MVPA; screen time	Past week	45	F; D; I
MARCA ⁷³	Children and adolescents (9–13.5 y), Australia	Self-reported	All forms of activity (organized and non-organized physical activity, sedentary activity, incidental activity, etc)	Continuous; time spent in each activity	MET-weighted average was computed; score based on time spend on sedentary behavior	PAL; MVPA; lying down, sitting, standing or in locomotion	Past day in weekday, weekend, holiday or day off from school	Segmented day format (web-based)	D; I; M
peas@tees ⁷⁴	Children and adolescents (9–10 y), England	Self-reported	Sedentary, household, and play activities, structured; transport	Continuous; time spent in each activity	MET-weighted average was computed; score based on time spend on sedentary behavior	MVPA	Usual day in school day and weekend day	Segmented day format (web-based)	D; I; M
HSK ⁷⁵	Children and adolescents (9–14 y), United States	Self-reported	Active play or sport; sedentary behaviors (TV; using computer; video games; on telephone)	Rating scale	h/d	Hours of active play or sport; hours of sedentary activities	Usual day of past month	2	F; D

(continued)

Table 1 (continued)

Questionnaire	Age group, country	Mode of administration	Domains	Response method	Units of measurement	Scores	Recall period/assessment period	No. of items	Parameters
PQPASB ⁷⁶	Children and adolescents (6–10 and 13–14 y), Swiss	Proxy-reported	For PA: leisure For SB: screen-time; study; leisure; reading	Rating scale: never, less than 30 min, 30 min to 1 h, 1–2 h, 2–4 h, and more than 4 h/d	min/d	SB score and PA score (the categorized time intervals were transformed into a continuous variable using the intervals' midpoints and an assumed maximum of 8 h); watching TV/video/DVD; sitting at a computer/playing Nintendo/electronic games; doing homework; reading; playing a musical instrument; playing quietly/other quiet activities; traveling by car/public transport; time spent outdoors; playing vigorously active indoors; playing vigorously active outdoors; cycling; time spent breathing hard and sweating; attending sports training (outside school); frequency of physical activity bouts with parents; active commuting to school; comparison with other children of the same age and sex	Usual week-day and week-end day	List of activities	F; D; M

(continued)

Table 1 (continued)

Questionnaire	Age group, country	Mode of administration	Domains	Response method	Units of measurement	Scores	Recall period/assessment period	No. of items	Parameters
Physical activity + sedentary behavior + sleep									
Daughter Questionnaire ⁷⁷	Children and adolescents (8.5–12.7 y), United Kingdom	Self-reported	Light activity (standing); moderate activity (walking); and vigorous activity (sports); TV/VCR/video games; ST; sleep	Continuous: h/d	h/d	Sleep; sitting; standing; walking; exercise; TV/VCR/video games	Usual day, in school day and weekend day	Three time-tables (school, weekend, TV)	D; I
Mother and Father Questionnaires ⁷⁷	Children and adolescents (8.5–12.7 y), United Kingdom	Proxy-reported	Light activity (standing); moderate activity (walking); and vigorous activity (sports); TV/VCR/video games; ST; sleep	Continuous: h/d	h/d	Sleep; sitting; standing; walking; exercise; TV/VCR/video games	Usual day, in school day and weekend day	?	D; I

Abbreviations: ?, doubtful; 3DPAR, 3-d Physical Activity Recall; APARQ, Adolescent Physical Activity Recall Questionnaire; CCTQ, Children's Chronotype Questionnaire; CLASS—Proxy and self. The Children's Leisure Activities Study Survey—Proxy and self-reported; CLASS—Proxy, The Children's Leisure Activities Study Survey—Proxy; cPAQ, computer-based physical activity questionnaire; D, duration; EAQT-SB, Eating and Activity Questionnaire Trial—Sedentary Behavior questions; ENERGY-C Q, ENERGY-Child Questionnaire; F, frequency; Fels PAQ, Fels Physical Activity Questionnaire; GAQ, GEMS Activity Questionnaire; HBSC PAQ, Health Behavior in Schoolchildren Physical Activity Questionnaire; Helena SB Q, HELENA screen time-based sedentary behavior questionnaire; HPAQ, Habitual Physical Activity Questionnaire; HSK, Heart Smart Kids; I, intensity; IPAQ, International Physical Activity Questionnaire; LPA, light physical activity; M, mode; MARCA, multimedia activity recall for children and adolescents; METs, Metabolic equivalent; MGLTEQ, Modified Godin-Leisure-Time Exercise Questionnaire; MoMo, MoMo-Physical-Activity-Questionnaire for Adolescents; MPA and VPA S Q, moderate and Vigorous Physical Activity Screening Questionnaire; MPA, Moderate Physical Activity; MVPA, moderate to vigorous physical activity; n, sample number; NSST, nonscreen sedentary time; O-O-S PAQ, Out-of-School Physical Activity Questionnaire; OPAQ, Oxford Physical Activity Questionnaire; PA, physical activity; PACE + PAM, PACE + adolescent physical activity measure; PAL, physical activity level; PACE, patient-centered assessment and counseling for exercise; POPASB, Parental Questionnaire for Physical Activity and Sedentary Behavior; PYPAA, past year physical activity in adolescents; SAPAC, Self-Administered Physical Activity Checklist; SAYCARE PA Q A, SAYCARE Physical Activity Questionnaire for adolescents; SAYCARE PA Q C, SAYCARE Physical Activity Questionnaire for children; SAYCARE SB Q A, South American Youth Cardiovascular and Environmental sedentary behavior questionnaire for adolescents; SAYCARE SB Q C, South American Youth Cardiovascular and Environmental sedentary behavior questionnaire for Children; SB, sedentary behavior; SHAPES, School Health Action, Planning and Evaluation System; S-I PA M, single-item physical activity measure; SIT-Q-7d, last-7-d sedentary behavior questionnaire; ST, sitting time; VPA, vigorous physical activity; YLSBQ, Youth Leisure-time Sedentary Behavior Questionnaire; YRBS, Youth Risk Behavior Survey.

Table 2 Validity Results

Questionnaire	Sample		Validity		Overall quality
	n; %girls; age mean (SD) or age range, y	Type of validity	Comparison measure	Results	
PA					
CLASS—Proxy ³⁰	58; 63% girls; 5–6 y	Criterion	Accelerometer, ActiGraph AM7164-2.2C; wear time: N.R.; site: N.R.; epoch: N.R.	MPA (rho = −0.06); VPA (rho = −0.04); total PA (rho = −0.04); total accelerometer raw movement counts per day (rho = 0.05)	—
SAYCARE PA Q C ⁵⁰	Children: 82; 54.4% girls; 3–10 y	Criterion	Accelerometer, ActiGraph GTX3, wear time: 7 d; site: hip mounted; epoch: 5 s	MPA (rho = 0.60*); VPA (rho = 0.27); total PA (rho = 0.44*); agreement guidelines (kappa = .40)	—
O-O-S PAQ ⁵¹	126; N.R.; 11 y	Criterion	Accelerometer, ActiGraph GTX3, wear time: 7 d; site: hip mounted; epoch: 15 s	MVPA duration (r = .25); MVPA frequency (r = .25)	—
HPAQ ⁵²	94; 68.1% girls; 11–16 y	Convergent	VO ₂ max (ml/kg/min)	Weekly physical activity score (rho = 0.15); yearly physical activity score (rho = 0.23)	—
			Total speed (km/h)	Weekly physical activity score (rho = 0.14); yearly physical activity score (rho = 0.23)	—
			Total time (s)	Weekly physical activity score (rho = 0.14); yearly physical activity score (rho = 0.26)	—
			Maximum heart rate	Weekly physical activity score (rho = 0.10); yearly physical activity score (rho = 0.16)	—
			Waist circumference (cm)	Weekly physical activity score (rho = −0.12); yearly physical activity score (rho = −0.06)	—
3DPAR ⁵³	157; N.R.; 11–14 y	Criterion	Accelerometer, ActiGraph (empirical thresholds); wear time: 3 d; site: N.R.; epoch: 30 s	Overall period MVPA (r = .28**); Monday MVPA (r = .49***); Sunday MVPA (r = .26**); Saturday MVPA (r = .06); overall period VPA (r = .16); Monday VPA (r = .31**); Sunday VPA (r = .15); Saturday VPA (r = .02)	—
			Accelerometer, ActiGraph (standard thresholds); wear time: 3 d; site: N.R.; epoch: 30 s	Overall period MVPA (r = .20); Monday MVPA (r = .24*); Sunday MVPA (r = .19); Saturday MVPA (r = .16); overall period VPA (r = .29**); Monday VPA (r = .42***); Sunday VPA (r = .18); Saturday VPA (r = .24**)	—
YRBS ⁵⁴	125; 52.5% girls; 12.2 (0.6)	Criterion	Accelerometer, ActiGraph model 7164; wear time: 7 d; site: hip; epoch: 60 s	Meeting MPA guideline (≥30 min/d for ≥5 d/wk) = 20.8% of agreement; sensitivity = 0.23; specificity = 0.92; meeting VPA guideline (≥20 min/d for ≥3 d/wk) = 19.2% of agreement; sensitivity = 0.86	?
SAPAC ⁵³	154; N.R.; 11–14 y	Criterion	Accelerometer, ActiGraph (empirical thresholds); wear time: 3 d; site: N.R.; epoch: 30 s	Overall period MVPA (r = .24**); Monday MVPA (r = .31**); Sunday MVPA (r = .18); Saturday MVPA (r = .21*); overall period VPA (r = .28**); Monday VPA (r = .44); Sunday VPA (r = .15); Saturday VPA (r = .23*)	—
			Accelerometer, ActiGraph (standard thresholds); wear time: 3 d; site: N.R.; epoch: 30 s	Overall period MVPA (r = .31***); Monday MVPA (r = .50***); Sunday MVPA (r = .28**); Saturday MVPA (r = .14); overall period VPA (r = .19); Monday VPA (r = .32***); Sunday VPA (r = .19*); Saturday VPA (r = .04)	—
HBSC PAQ ⁵⁵	67; 55% girls; 13–18 y	Convergent	VO ₂ peak	Frequency (rho = 0.39**); duration (rho = 0.33**); frequency categories (rho = 0.36**); duration categories (rho = 0.29*)	—
		Criterion	Accelerometer, ActiReg (total energy expenditure); wear time: 7 d; site: chest and thigh; epoch: N.R.	Frequency (rho = 0.20); duration (rho = 0.23); frequency categories (rho = 0.22); duration categories (rho = 0.22)	—
			Accelerometer, ActiReg (average physical activity level); wear time: 7 d; site: chest and thigh; epoch: N.R.	Frequency (rho = 0.02); duration (rho = 0.01); frequency categories (rho = 0.02); duration categories (rho = −0.02)	—

(continued)

Table 2 (continued)

Sample			Validity		Overall quality
Questionnaire	n; %girls; age mean (SD) or age range, y	Type of validity	Comparison measure	Results	
MGLTEQ ⁵⁶	114; 59.6% girls; 12–14 y	Criterion	Accelerometer, ActiGraph; wear time: 7 d; site: right hip; epoch: 60 s	MPA ($r = .23^{**}$); VPA ($r = .13$)	–
OPAQ ⁵⁷	51; 47.1% girls; N.R.	Criterion	Accelerometer, Caltrac; wear time: 4 d; site: waist; epoch: N.R.	VPA ($r = .33^{**}$); MVPA ($r = .32^{**}$); MPA ($r = .01$)	–
APARQ ⁵⁸	1072; 48% girls; 12.1 y; grade 8	Convergent	20-m shuttle run test	Energy expenditure boys ($r = .15^{***}$); energy expenditure girls ($r = .21^{***}$)	–
	954; 45% girls; 15.1 y; grade 10			Energy expenditure boys ($r = .14^{**}$); energy expenditure girls ($r = .39^{***}$)	–
PYPAA ⁵⁹	100; 53% girls; 16.6 y	Convergent	BMI	Boys: h/wk ($\rho = -0.04$), MET-h/wk ($\rho = -0.06$), VPA-h/wk ($\rho = -0.13$); girls: h/wk ($\rho = -0.09$), MET-h/wk ($\rho = -0.13$), VPA-h/wk ($\rho = -0.08$)	–
			1-mile run	Boys: h/wk ($\rho = -0.18$), MET-h/wk ($\rho = -0.20$), VPA-h/wk ($\rho = -0.13$); girls: h/wk ($\rho = -0.43^{**}$), MET-h/wk ($\rho = -0.47^{*}$), VPA-h/wk ($\rho = -0.45^{*}$)	–
			Sit and reach	Boys: h/wk ($\rho = 0.15$), MET-h/wk ($\rho = 0.15$), VPA-h/wk ($\rho = 0.04$); girls: h/wk ($\rho = 0.15$), MET-h/wk ($\rho = 0.14$), VPA-h/wk ($\rho = 0.02$)	–
			Pull-ups	Boys: h/wk ($\rho = 0.17$), MET-h/wk ($\rho = 0.16$), VPA-h/wk ($\rho = -0.01$); girls: h/wk ($\rho = -0.06$), MET-h/wk ($\rho = -0.06$), VPA-h/wk ($\rho = -0.06$)	–
			Grip strength	Boys: h/wk ($\rho = 0.04$), MET-h/wk ($\rho = 0.04$), VPA-h/wk ($\rho = -0.02$); girls: h/wk ($\rho = 0.05$), MET-h/wk ($\rho = 0.14$), VPA-h/wk ($\rho = 0.25$)	–
cPAQ ⁶⁰	180; N.R.; N.R.	Convergent	7-d PALog	Total PA duration, min/d: boys ($\rho = 0.72^{***}$); total PA duration, min/d: girls ($\rho = 0.54^{***}$); total PA duration, min/d: both ($\rho = 0.63^{***}$); Bland-Altman (data not shown): reasonably good agreement between the cPAQ and PALog, with most PA measures fell within a mean ± 2 SD	+
S-I PA M ⁶¹	123; 38.2%; 14.7 (0.5) y	Criterion	Accelerometer, ActiGraph; wear time: 7 d; site: waist belt; epoch: 15 s	MVPA (accelerometer wear time of 480 MVPA min/d criteria; $r = .43$ [95% CI, .23 to .62] ^{***}); MVPA (accelerometer wear time of 600 MVPA min/d criteria; $r = .44$ [95% CI, .24 to .63] ^{***})	–
MPA and VPA S Q ⁵⁴	57; 65% girls; 13.9 (1.7) y	Criterion	Accelerometer, CSA; wear time: 7 d; site: right hip; epoch: N.R.	VPA typical week ($r = .31$); VPA past week ($r = .36$); VPA composite ($r = .37$); 30-min MPA typical week ($r = .20$); 30-min MPA past week ($r = .26$); 30-min MPA composite ($r = .26$); 60-min MPA typical week ($r = .46$); 60-min MPA past week ($r = .37$); 60-min MPA composite ($r = .47$)	–
PACE + PAM ⁵⁴	138; 65% girls; 12.1 (0.9) y	Criterion	Accelerometer, CSA; wear time: 7 d; site: right hip; epoch: N.R.	MVPA ($r = .40^{**}$)	–
SAYCARE PA Q A ⁵⁰	Adolescents: 60; 55.7% girls; 11–18 y	Criterion	Accelerometer GTX3; wear time: 7 d; site: waist; epoch: 5 s	MPA ($\rho = 0.11$); VPA ($\rho = 0.65^{*}$); total PA ($\rho = 0.88^{*}$); adolescent kappa agreement guidelines ($\kappa = .51^{*}$)	–
Fels PAQ ⁶²	229; 56.7%; 7–19 y	Criterion	Accelerometer, Actiwatch; wear time: 6 d; site: N.R.; epoch: 60 s	Elementary school: total score ($r = .32$), sport score ($r = .32$), leisure score ($r = .28$), work score ($r = .08$); middle school: total score ($r = .12$), sport score ($r = .07$), leisure score ($r = .28$), work score ($r = -.13$); high school: total score ($r = .11$), sport score ($r = .34$), leisure score ($r = .20$), work score ($r = -.08$)	–
MoMo ⁶³	109; 44% girls; 8–17 y	Criterion	Accelerometer, ActiGraph GT1M; wear time: N.R.; site: N.R.; epoch: N.R.	General PA ($r = .29$); PA in school ($r = .04$); recreational sports outside clubs ($r = .10$)	–

(continued)

Table 2 (continued)

Sample			Validity		Overall quality
Questionnaire	n; %girls; age mean (SD) or age range, y	Type of validity	Comparison measure	Results	
SB					
SAYCARE SB Q C ⁶⁴	93; 50% girls; 3–10 y	Criterion	Accelerometer, ActiGraph GT3X; wear time: 7 d; site: waist; epoch: 5 s	SB weekdays (min/d) ($\rho = -0.10$); SB weekend days (min/d) ($\rho = 0.40^{**}$); SB total days (min/d) ($\rho = 0.07$); SB weekdays (Bland–Altman: mean difference = -459.5 [100.9] min/d; LoA = -661.4 to -257.6 min/d); SB weekend (Bland–Altman: mean difference = -332.6 (138.5) min/d; LoA = -609.6 to -55.6 min/d); SB total days (Bland–Altman: mean difference = -420.2 [100.3] min/d; LoA = -620.9 to -219.5)	–
EAQT-SB ⁶⁵	245; 58.8%; 11–15 y	Convergent	Log of TV viewing and computer use daily during 7 d	Weekday TV ($\rho = 0.46^{***}$); weekend TV ($\rho = 0.37^{***}$); weekday average TV ($\rho = 0.47^{***}$); computer use ($\rho = 0.40^{**}$)	–
Helena SB Q ⁶⁶	2048; 59.2% girls; 12.5–17.5 y	Criterion	Accelerometer, ActiGraph GT1M, wear time: 7 d; site: lower back; epoch: N.R.	Girls: TV viewing—not significant, computer use—not significant, console games—not significant, internet nonstudy— $P \leq .05$ between tertile 1 and tertile 2, internet for study—not significant; Boys: TV viewing—not significant, computer use— $P \leq .05$ between tertile 1 and tertile 3 and tertile 2 and tertile 3, console games—not significant, internet nonstudy— $P \leq .05$ between tertile 1 and tertile 3, internet for study— $P \leq .05$ between tertile 1 and tertile 2 and between tertile 1 and tertile 3, study— $P \leq .05$ between tertile 1 and tertile 3 and between tertile 2 and tertile 3, total SB weekdays— $P \leq .05$ between tertile 1 and tertile 2 and between tertile 1 and tertile 3, total SB weekend days— $P \leq .05$ between tertile 1 and tertile 3, internet for study— $P \leq .05$ between tertile 1 and tertile 2 and between tertile 1 and tertile 3	–
SIT-Q-7d ⁶⁷	62; 58% girls; 15–16 y	Criterion	activPAL; wear time: N.R.; site: N.R.; epoch: N.R.	SB weekday total ($\rho = 0.42^{***}$); SB weekend day total ($\rho = 0.02$); SB average day total ($\rho = 0.29^*$)	–
SAYCARE SB Q A ⁶⁴	94; 50% girls; 11–18 y	Criterion	Accelerometer, ActiGraph GT3X; wear time: 7 d; site: waist; epoch: 5 s	SB weekdays (min/d) ($\rho = -0.11$); SB weekend days (min/d) ($\rho = 0.36^{**}$); SB total days (min/d) ($\rho = 0.05$); SB weekdays (Bland–Altman: mean difference = -449.3 [87.0] min/d; LoA = -623.3 to -275.3 min/d); SB weekend days (Bland–Altman: mean difference = -399.7 [105.0] min/d; LoA = -609.6 to -189.7 min/d); SB total days (Bland–Altman: mean difference = -435.1 [66.3] min/d; LoA = -566.6 to -302.6)	–
YLSBQ ⁶⁸	1207; N.R.; 8–18 years	Criterion	Accelerometer, ActiGraph; wear time: 7 d; site: lower back; epoch: 2 s	Weekday sitting time ($r = .36^{***}$); weekend sitting time ($r = .20^{**}$); average day sitting time ($r = .36^{**}$); average day (Bland–Altman: mean difference = 19.86 min/d; LoA = -280.04 to 319.76 min/d); average day (Bland–Altman: mean difference = 19.86 min/d; LoA = -280.04 to 319.76 min/d); weekdays (Bland–Altman: mean difference = 5.63 min/d; LoA = -246.17 to 257.43 min/d); weekend days (Bland–Altman: mean difference = 45.24 min/d; LoA = -298.54 to 389.02 min/d)	–
Sleep CCTQ ⁶⁹	85; N.R.; 4–11 y	Criterion	Accelerometer, Actiwatch Plus (AW4), wear time: 6–14 d; site: nondominant wrist; epoch: 60 s	Sleep period (weekday) $d = 0.59^{***}$; sleep period (weekend day) $d = 0.83^{***}$	–
PA + SB GAQ ⁷⁰	68; 100% girls; 8–9 y	Criterion	Accelerometer, MTI/CSA; wear time: N.R.; site: N.R.; epoch: 60 s	18 physical activities/past day (MET weighted score) ($r = .28^*$); 18 physical activities/usual day (MET weighted score) ($r = .30^*$)	–

(continued)

Table 2 (continued)

Questionnaire	Sample		Type of validity	Comparison measure	Validity		Overall quality
	n; %girls; age mean (SD) or age range, y				Results		
ENERGY-C Q ⁷¹	96; N.R.; 10–12 y	Convergent	Interview		Bike to school (d/wk) (ICC = .81; %agreement = 73%); bike to school (min/d) (ICC = .66; %agreement = 75%); walk to school (d/wk) (ICC = .84; %agreement = 75%); walk to school (min/d) (ICC = .59; %agreement = 74%); car to school (d/wk) (ICC = .84; %agreement = 80%); public transport to school (d/wk) (ICC = .81; %agreement = 96%); one sport (h/wk) (ICC = .71; %agreement = 50%); second sport (h/wk) (ICC = 1.00; %agreement = 36%); sport past day (h/wk) (ICC = .22; %agreement = 50%); computer use in free time (h/weekday) (ICC = .35); computer use in free time (h/weekend day) (ICC = .67; %agreement = 37%); TV (h/past day) (ICC = .70; %agreement = 44%); computer use in free time (h/past day) (ICC = .28; %agreement = 39%)	–	–
IPAQ ⁵⁵	67; 55% girls; 13–18 y	Convergent	VO ₂ peak		VPA d/wk (rho = 0.26*); VPA min/d (rho = –0.32*); MPA d/wk (rho = –0.03); MPA min/d (rho = 0.13); walking days/wk (rho = 0.12); walking min/d (rho = –0.14); sitting min/d (rho = 0.18); 3 categories (“low,” “moderate,” and “high” activities; rho = 0.32**)	–	–
		Criterion	Accelerometer, ActiReg (total energy expenditure); wear time: 7 d; site: chest and thigh		VPA d/wk (rho = 0.19); VPA min/d (rho = –0.14); MPA d/wk (rho = 0.07); MPA min/d (rho = 0.01); walking days/wk (rho = 0.15); walking min/d (rho = 0.24); sitting min/d (rho = –0.04); 3 categories (“low,” “moderate,” and “high” activities; rho = 0.09)	–	–
			Accelerometer, ActiReg (average physical activity level); wear time: 7 d; site: chest and thigh		VPA d/wk (rho = 0.09); VPA min/d (rho = –0.08); MPA d/wk (rho = 0.05); MPA min/d (rho = 0.01); walking d/wk (rho = 0.13); walking min/d (rho = 0.43**); sitting min/d (rho = –0.29); 3 categories (“low,” “moderate,” and “high” activities; rho = –0.03)	–	–
SHAPES ⁷²	53; 47% girls; N.R.	Criterion	Accelerometer, ActiGraph AM7164; wear time: N.R.; site: right hip; epoch: 60 s		MVPA min/d ($r = .44^*$); VPA min/d ($r = .25$); MPA min/d ($r = .31^*$); energy expenditure daily average ($r = .44^{***}$)	–	–
MARCA ⁷³	66; 50% girls; 9–13 y	Criterion	Accelerometer, ActiGraph; wear time: 1 d; site: N.R.; epoch: 60 s		PAL ($r = .45^{**}$); MVPA min ($r = .35$)**; locomotion min ($r = .37^{**}$)	–	–
peas@tees ⁷⁴	157; N.R.; N.R.	Criterion	Accelerometer, ActiGraph GT-256; wear time: 5 d; site: right hip; epoch: 60 s		MVPA min (rho = 0.23*); MVPA (LoA = –146 to 105 [95% CI, –31 to –111] min/d; bias = –21 min/d)	–	–
HSK ⁷⁵	103; 91% girls; 9–14 y	Convergent	HABITS questionnaire		Activity (rho = 0.38***); sedentary (rho = 0.65***)	–	–
PQPASB ⁷⁶	167; 71% girls; 6–10 and 13–14 y	Criterion	Accelerometer, ActiGraph Model AM7164; wear time: 7 d; epoch: 60 s		SB score (rho = 0.55***); watching TV/video/DVD (rho = 0.32***); sitting at a computer/playing Nintendo/electronic games (rho = 0.32***); doing homework (rho = 0.53***); reading (rho = 0.32); playing a musical instrument (rho = 0.12); playing quietly/other quiet activities (rho = –0.10); traveling by car/public transport (rho = 0.05); PA score (rho = 0.46**); time spent outdoors (rho = 0.33***); playing vigorously active indoors (rho = 0.30***); playing vigorously active outdoors (rho = 0.48***)	–	–

(continued)

Table 2 (continued)

Questionnaire	Sample		Type of validity	Comparison measure	Validity		Overall quality
	n; %girls; age mean (SD) or age range, y				Results		
PA + SB + sleep							
Daughter Questionnaire ⁷⁷	69 girls; 8.5–12.7 y	Convergent	Activity diary		Cycling (rho = 0.19*); time spent breathing hard and sweating (rho = 0.15); attending sports training (outside school) (rho = -0.15)		–
					School day: sleeping (ICC = .52), sitting (ICC = .40), standing/light (ICC = .29), walking/moderate (ICC = .46), exercising/vigorous (ICC = .19), TV/VCR/video games (ICC = .38); weekend day: sleeping (ICC = .32), sitting (ICC = .32), standing/light (ICC = .42), walking/moderate (ICC = .25), exercising/vigorous (ICC = .23), TV/VCR/video games (ICC = .31)		–
Mother and Father Questionnaires ⁷⁷	69 girls; 8.5–12.7 y	Convergent	Activity diary		Mothers, school day: sleeping (ICC = -.35), sitting (ICC = .03), standing/light (ICC = -.22), walking/moderate (ICC = .18), exercising/vigorous (ICC = -.03), TV/VCR/video games (ICC = .54); mothers, weekend day: sleeping (ICC = -.37), sitting (ICC = .15), standing/light (ICC = -.24), walking/moderate (ICC = .39), exercising/vigorous (ICC = .4), TV/VCR/video games (ICC = .31); fathers, school day: sleeping (ICC = -.46), sitting (ICC = .04), standing/light (ICC = -.40), walking/moderate (ICC = .07), exercising/vigorous (ICC = -.04), TV/VCR/video games (ICC = .52); fathers, weekend day: sleeping (ICC = -.38), sitting (ICC = .10), standing/light (ICC = -.37), walking/moderate (ICC = .15), exercising/vigorous (ICC = .05), TV/VCR/video games (ICC = .40)		–

Abbreviations: –, inadequate; +, adequate; ?, doubtful; 3DPAR, 3-d Physical Activity Recall; 7-d PALog, 7 day physical activity log; APARQ, Adolescent Physical Activity Recall Questionnaire; BMI, body mass index; CCTQ, Children's ChronoType Questionnaire; CI, confidence interval; CLASS—Proxy and self, The Children's Leisure Activities Study Survey—Proxy and self-reported; CLASS—Proxy, The Children's Leisure Activities Study Survey—Proxy; cPAQ, computer-based physical activity questionnaire; CSA, Computer Science Application; EAQT-SB, Eating and Activity Questionnaire Trial—Sedentary Behavior questions; ENERGY-C Q, ENERGY-Child Questionnaire; Fels PAQ, Fels Physical Activity Questionnaire; GAQ, GEMS Activity Questionnaire; HBSC PAQ, Health Behavior in Schoolchildren Physical Activity Questionnaire; Helena SB Q, HELENA screen time-based sedentary behavior questionnaire; HPAQ, Habitual Physical Activity Questionnaire; HSK, Heart Smart Kids; ICC, intraclass correlation coefficient; IPAQ, International Physical Activity Questionnaire; LoA, limits of agreement; LPA, light physical activity; MARCA, multimedia activity recall for children and adolescents; MGLTEQ, Modified Godin Leisure-Time Exercise Questionnaire; MoMo, MoMo-Physical-Activity-Questionnaire for Adolescents; MPA and VPA S Q, moderate and Vigorous Physical Activity Screening Questionnaire; MPA, Moderate Physical Activity; MTI, Manufacturing Technology Inc., MVPA, moderate to vigorous physical activity; n, sample number; N.R., not reported; NSST, nonscreen sedentary time; O-O-S PAQ, Out-of-School Physical Activity Questionnaire; OPAQ, Oxford Physical Activity Questionnaire; PA, physical activity; PACE + PAM, PACE + Adolescent Physical Activity Measure; PAL, physical activity level; PQPASB, Parental Questionnaire for Physical Activity and Sedentary Behavior; PYPAA, past year physical activity in adolescents; SAPAC, Self-Administered Physical Activity Checklist; SAYCARE PA Q A, SAYCARE Physical Activity Questionnaire for adolescents; SAYCARE PA Q C, SAYCARE Physical Activity Questionnaire for children; SAYCARE SB Q A, South American Youth Cardiovascular and Environmental sedentary behavior questionnaire for adolescents; SAYCARE SB Q C, South American Youth Cardiovascular and Environmental sedentary behavior questionnaire for Children; SB, sedentary behavior; SHAPEs, School Health Action, Planning and Evaluation System; S-IPA M, single-item physical activity measure; SIT-Q-7d, last-7-d sedentary behavior questionnaire; ST, sitting time; VPA, vigorous physical activity; YLSBQ, Youth Leisure-time Sedentary Behavior Questionnaire; YRBS, Youth Risk Behavior Survey. * $P \leq 0.05$; ** $P \leq 0.001$; *** $P \leq 0.0001$.

Concerning the questionnaires combining PA and SB, none showed overall criterion or convergent validity. The accelerometer was the criterion measure used to assess criterion validity, in all questionnaires. Regarding criterion validity, none of the questionnaires were rated with “adequate” criterion validity. Convergent validity was measured in the ENERGY-Child Questionnaire,⁷¹ International Physical Activity Questionnaire,⁵⁵ and Heart Smart Kids.⁷⁵ Some scores of the ENERGY-Child Questionnaire⁷¹ were considered to have “adequate” convergent validity, against an interview.

Regarding questionnaires combining all movement behaviors, both were evaluated against a convergent measure (diary), and only the sleeping score from the Daughter Questionnaire⁷⁷ showed “adequate” validity (ICC = .52).

Concerning the validity of the various domains of the movement behaviors (eg, the different PA intensities), there were no clear differences between domains and no patterns were identified favoring one domain over another.

Reliability and Measurement Error. Table 3 shows the summary of the questionnaires’ reliability results. The time between test and retest ranged from 1 day to 1 year. The most often used statistical approaches to assess reliability were correlations (Pearson and Spearman) and ICCs. Measurement error was evaluated only in the multimedia activity recall for children and adolescents (MARCA)⁷³ questionnaire. The overall measurement error quality for the MARCA was rated as “doubtful” due to the minimal important change not reported.

Seven questionnaires showed overall “adequate” reliability: 5 PA questionnaires (the Children’s Leisure Activities Study Survey—Proxy,³⁰ Health Behavior in Schoolchildren Physical Activity Questionnaire,⁵⁵ Oxford Physical Activity Questionnaire,⁵⁷ single-item physical activity measure,⁶¹ and PACE + adolescent physical activity measure⁵⁴); 1 SB questionnaire (HELENA screen time-based sedentary behavior questionnaire⁶⁶); and the sleep questionnaire (Children’s ChronoType Questionnaire⁶⁹).

Risk of Bias

Table 4 shows the summary of the risk of bias (RoB) results (details provided in [Supplementary Material S5](#) [available online]). The overall RoB rating for criterion validity was “very low” for 92% of the criterion validity studies. The main cause for the high RoB was the lack of reporting correlation coefficients results. For convergent validity, 72.7% of the studies were classified with overall “high” RoB, with the main reason being insufficient or unknown measurement properties of the comparator. For the overall reliability RoB, 27.3% of the studies were rated with a “very low” RoB; the main reason was an inappropriate interval between test and retest, the absence of similar test conditions in both measurements, and the statistical methods used (eg, correlations instead of ICCs). For the overall RoB rating for measurement error, the MARCA⁷³ questionnaire was classified with “very low” RoB.

Summary of Findings

Table 4 summarizes the results of the content, convergent and criterion validity, reliability, measurement error, and RoB for each measurement property.

Discussion

This systematic review described questionnaires measuring sleep, SB, and PA, or its combination, in children and adolescents,

and included 30 self-reported questionnaires and 7 proxy-reported. Contentwise, the questionnaires varied in the assessed domains, response method, measurement units, scores, recall, and assessment periods; such diversity between questionnaires hindered comparisons between them and the choice of some over others. Concerning validity, none of the questionnaires showed overall “adequate” criterion validity, and the RoB was “very low” in 92% of the studies with criterion validity. Only one questionnaire showed “adequate” convergent validity,⁶⁰ and 72.7% of the studies were rated with an overall “high” RoB. Seven questionnaires showed “adequate” reliability and 27.3% of the studies were rated with a “very low” RoB. However, no questionnaires showed “adequate” criterion validity and reliability simultaneously.

The proxy-reported questionnaires were mostly directed at parents or caregivers of children aged 3–10 years, and only the The Children’s Leisure Activities Study Survey—Proxy³⁰ and Children’s ChronoType Questionnaire⁶⁹ showed “adequate” reliability. None of the proxy-reported questionnaires showed “adequate” validity. Indeed, the younger the children, the more difficult it is for them to report past movement behaviors.¹⁷ This review did not find proxy reports directed at toddlers’ parents or caregivers. Considering that the 24-hour movement guidelines have been developed for young children^{4,6,7}, there is a need for proxy reports with adequate validity and reliability for this age group.

Following the cutoff points suggested by COSMIN,³⁷ the quality of the questionnaires’ validity was frequently considered “inadequate.” This may happen because questionnaires are known to have several limitations (eg, measurement error and reporting bias due to social desirability, language, interpretation, questionnaire’s complexity, age, and seasonal variation^{8,18,19,22}), particularly when applied to children and adolescents, where issues related to recall or comprehension of the questionnaires,¹⁷ and the unstable patterns of movement behaviors throughout the day,^{24,25} may be more present than in adults. For these reasons, proxy reports by parents and other caregivers may be a possible solution,^{27–30} despite the known difficulties of this method.⁷⁸

Regarding reliability, the overall quality of the results was frequently “inadequate.” Furthermore, the statistical procedures used were often considered “inadequate,” especially due to the commonly use of Pearson or Spearman correlations, instead of ICCs or kappas, as it has been suggested.⁷⁹ Seven questionnaires showed overall “adequate” reliability (5 PA questionnaires^{30,54,55,57,61}; 1 SB questionnaire,⁶⁶ and the sleep questionnaire⁶⁹). However, none of these questionnaires showed “adequate” validity; a required criteria for questionnaire validation purposes (ie, a questionnaire must present at least “adequate” overall validity and reliability^{37,41}). Low validity and reliability were also found in other similar reviews,^{8,9,31–34} which also reported several methodological limitations of the included questionnaires. Furthermore, if the development method and the measurement properties are poor or not well clarified, the risk of misclassification, bias, and inaccurate results is high.²³

Our results align with a recently published systematic review⁸⁰ on measurement properties of 24-hour movement behavior questionnaires, in adults and older adults, which reported several methodologic limitations in the included questionnaires, showing inadequate validity and reliability scores and insufficient measurement properties.

From a public health and epidemiology point of view, given the intrinsic and empirical interactions between sleep, SB, and PA, there is a tangible need to develop accurate self-reported and proxy-reported questionnaires, to measure movement behaviors levels in

Table 3 Reliability Results

Questionnaire	Sample		Reliability		Overall quality
	n; %girls; age mean (SD) or age range, y	Time between test and retest	Results		
PA					
CLASS—Proxy ³⁰	58; 63% girls; 5–6 y	At least 14 d	Total MPA frequency (ICC = .74***); total MPA duration (ICC = .49***); overall total PA frequency (ICC = .83***); overall total PA duration (ICC = .76***)		+
SAYCARE PA Q ⁵⁰	49.8% girls; 3–10 y	15 d	PA commuting (rho = 0.28); PA school (rho = 0.31*); leisure PA (rho = 0.33*); MPA (rho = 0.37*); VPA (rho = 0.89*); total PA (rho = 0.56*); agreement guidelines kappa = .32		–
O-O-S PAQ ⁵¹	151; N.R.; 11 y	30 d	MVPA duration (ICC = .65); MVPA frequency (ICC = .64)		–
HPAQ ⁵²	94; 68.1% girls; 11–16 y	2 wk	Weekly physical activity score (ICC = .61); yearly physical activity score (ICC = .68)		–
3DPAR ⁵³	92; N.R.; 11–14 y	1 d	Overall period MVPA (r = .67*); Monday MVPA (r = .66*); Sunday MVPA (r = .49*); overall period VPA (r = .63*); Monday VPA (r = .73*); Sunday VPA (r = .37)		–
YRBS ⁵⁴	125; 52.5% girls; 12.2 (0.6) y	15 d	MPA item (ICC = .51*); VPA item (ICC = .46*)		–
SAPAC ⁵³	65; N.R.; 11–14 y	1 d	Overall period MVPA (r = .68*); Monday MVPA (r = .71*); Sunday MVPA (r = .63*); overall period VPA (r = .83*); Monday VPA (r = .69*); Sunday VPA (r = .82*); overall period MVPA (r = .68*)		–
HBSC PAQ ⁵⁵	71; 56.3% girls; 13–18 y	8–12 d	Frequency (ICC = .73); duration (ICC = .71)		+
MGLTEQ ⁵⁶	250; 58.8% girls; 12–14 y	1 wk	Mild-intensity school time (r = .48**); %agreement = 35.6%; kappa = .40; MPA school time (r = .51**); %agreement = 27.6%; kappa = .36; VPA school time (r = .68**); %agreement = 33.2%; kappa = .49; mild-intensity summertime (r = .56**); %agreement = 34.8%; kappa = .43; MPA summertime (r = .50**); %agreement = 26.4%; kappa = .38; VPA summertime (r = .56**); %agreement = 24.8%; kappa = .37)		–
OPAQ ⁵⁷	87; 44.8% girls; N.R.	2 wk	MPA (ICC = .76*); VPA (ICC = .80*); MVPA (ICC = .91*)		+
APARQ ⁵⁸	121; 48% girls, 12.7 y	2 wk	Grade 8, boys: summer total energy expenditure (ICC = .30), summer organized energy expenditure (ICC = .39), summer nonorganized energy expenditure (ICC = .30), winter total energy expenditure (ICC = .49), winter organized energy expenditure (ICC = .64), winter nonorganized energy expenditure (ICC = .54); grade 8, girls: summer total energy expenditure (ICC = .52), summer organized energy expenditure (ICC = .50), summer nonorganized energy expenditure (ICC = .48), winter total energy expenditure (ICC = .36), winter organized energy expenditure (ICC = .41), winter nonorganized energy expenditure (ICC = .33); grade 10, boys: summer total energy expenditure (ICC = .79), summer organized energy expenditure (ICC = .52), summer nonorganized energy expenditure (ICC = .68), winter total energy expenditure (ICC = .52), winter organized energy expenditure (ICC = .40), winter nonorganized energy expenditure (ICC = .65); grade 10, girls: summer total energy expenditure (ICC = .86), summer organized energy expenditure (ICC = .87), summer nonorganized energy expenditure (ICC = .86), winter total energy expenditure (ICC = .91), winter organized energy expenditure (ICC = .63), winter nonorganized energy expenditure (ICC = .90) h/wk (rho = 0.79); MET-h/wk (rho = 0.85**); VIG-h/wk (rho = 0.91**)		–
PYPAA ⁵⁹	100; 53% girls; 16.6 y	1 mo	h/wk (rho = 0.66**); MET-h/wk (rho = 0.72**); VIG-h/wk (rho = 0.72**)		–
cPAQ ⁶⁰	35 Malaysian boys; N.R. 45 Chinese boys; N.R. 59 Malaysian girls; N.R. 64 Chinese girls; N.R.	1 y 2 wk	Total PA, h/wk (ICC = .90*); LPA (ICC = .93*); MPA (ICC = .43); VPA (ICC = .68*) Total PA, h/wk (ICC = .91*); LPA (ICC = .63*); MPA (ICC = .79*); VPA (ICC = .87*) Total PA, h/wk (ICC = .51*); LPA (ICC = .26); MPA (ICC = .71*); VPA (ICC = .71*) Total PA, h/wk (ICC = .84*); LPA (ICC = .75*); MPA (ICC = .86*); VPA (ICC = .69*) MVPA (ICC = .75***)		–
S-I PA M ⁶¹	123; 38.2%; 14.7 (0.5) y	2 wk			+

(continued)

Table 3 (continued)

Questionnaire	Sample		Reliability		Overall quality
	n; %girls; age mean (SD) or age range, y	Time between test and retest	Results		
MPA and VPA S Q ⁵⁴	250; 56% girls; 14.6 (1.4) y	2 wk	VPA typical week (ICC = .67); VPA past week (ICC = .66); VPA composite (ICC = .76); 30-min MPA typical week (ICC = .55); 30-min MPA past week (ICC = .64); 30-min MPA composite (ICC = .71); 60-min MPA typical week (ICC = .65); 60-min MPA past week (ICC = .72); 60-min MPA composite (ICC = .79)	–	
PACE + PAM ⁵⁴	73; 65% girls; 12.1 (0.9) y	24 h to 1 month	MVPA (ICC = .77)	+	
SAYCARE PA Q A ⁵⁰	177; 58.3% girls; 11–18 y		PA commuting (rho = 0.51*); PA school (rho = 0.63*); leisure PA (rho = 0.68*); MPA (rho = 0.36*); VPA (rho = 0.93*); total PA (rho = 0.60*); agreement guidelines (kappa = .56*)	–	
CLASS—Proxy and self ³⁰	111; 27% girls; 10–12 y	7 d (self-report) and at least 14 d (proxy-report)	Total MPA frequency (proxy: ICC = .67***; self-report: ICC = .57***); total MPA duration (proxy: ICC = .58***; self-reported: ICC = .37**); overall total PA frequency (proxy: ICC = .69***; self-reported: ICC = .36**); overall total PA duration (proxy: ICC = .74***; self-reported: ICC = .24)	–	
Fels PAQ ⁶²	229; 56.7%; 7–19 y	6 d	Elementary school: total score (r = .70), sport score (r = .62), leisure score (r = .54), work score (r = .48); middle school: total score (r = .62), sport score (r = .64), leisure score (r = .49), work score (r = .68); high school: total score (r = .71), sport score (r = .76), leisure score (r = .65), work score (r = .58)	–	
MoMo ⁶³	109; 44% girls; 8–17 y	1 wk	General PA (ICC = .74**); PA in school (ICC = .60**); recreational sports outside clubs (ICC = .64**)	–	
SB					
SAYCARE SB Q C ⁶⁴	55; 40% girls; 3–10 y	2 wk	Total SB time weekdays (min/d) (rho = 0.45**); total SB time weekend day (min/d) (rho = 0.51**); total SB time total days (min/d) (rho = 0.70*); meeting ≤120 min/d (%) weekdays (kappa = .52*); meeting ≤120 min/d (%) weekend days (kappa = .83*); meeting ≤120 min/d (%) total days (kappa = .83*)	–	
EAQT-SB ⁶⁵	245; 58.8%; 11–15 y	1 wk	Weekday TV (school period) (rho = 0.68***; kappa = .55; %agreement = 48.16); weekend TV (school period) (rho = 0.61***; kappa = .51; %agreement = 45.31); weekend TV (summer) (rho = 0.58***; kappa = .46; %agreement = 40.82); weekday TV (summer) (rho = 0.55***; kappa = .42; %agreement = 35.10); computer use (rho = 0.60***; kappa = .49; %agreement = 50.20)	–	
Helena SB Q ⁶⁶	183; 57%; 12.5–17.5 y	1 wk	TV week (kappa = .71); computer week (kappa = .82); computer week (kappa = .82); video games week (kappa = .82); internet nonstudy week (kappa = .86); internet study week (kappa = .46); study week (kappa = .73); TV weekend (kappa = .68); computer weekend (kappa = .79); video games weekend (kappa = .81); internet nonstudy weekend (kappa = .71); internet study weekend (kappa = .33)	+	
SIT-Q-7d ⁶⁷	20; 42% girls; 15–16 y	6 d	SB weekday total (ICC = .37); internet study weekend (kappa = .33); SB weekend day total (ICC = .67); SB average day total (ICC = .45)	–	
SAYCARE SB Q A ⁶⁴	106; 61%; 11–18 y		Total SB time weekdays (min/d) (rho = 0.39*); total SB time weekend day (min/d) (rho = 0.34**); total SB time total days (min/d) (rho = 0.50*); meeting ≤120 min/d (%) weekdays (kappa = .15*); meeting ≤120 min/d (%) weekend days kappa = .08*; meeting ≤120 min/d (%) total days (kappa = .17*)	–	

(continued)

Table 3 (continued)

Questionnaire	Sample		Reliability		Overall quality
	n; %girls; age mean (SD) or age range, y	Time between test and retest	Results		
YLSBQ ⁶⁸	194; 50.5%; 10–18 y	1 wk	Weekday: total sedentary time (ICC = .75*), screen time (ICC = .75*), watching TV/videos (ICC = .72*; kappa = .64**), playing computer/video games (ICC = .55*; kappa = .54**), internet surfing (ICC = .73*; kappa = .70**), nonscreen sedentary time—educational (ICC = .70), doing homework/study with computer (ICC = .62*; kappa = .51**), doing homework/study without computer (ICC = .58*; kappa = .53**), reading for fun (ICC = .83*; kappa = .74**), nonscreen sedentary time—social (ICC = .70*), sitting and talking (ICC = .34*; kappa = .27**), listening to music (ICC = .64*; kappa = .61**), talking on the telephone (ICC = .79*; kappa = .73**), nonscreen sedentary time—others (ICC = .57*), sitting to rest (ICC = .41*; kappa = .44**), doing cognitive hobbies (ICC = .46*; kappa = .43**), traveling on motorized transport (ICC = .60*; kappa = .54**); weekend day: total sedentary time (ICC = .72*), screen time (ICC = .74*), watching TV/videos (ICC = .66; kappa = .57**), playing computer/video games (ICC = .65*; kappa = .59**), internet surfing (ICC = .71*; kappa = .65**), nonscreen sedentary time—educational (ICC = .64*), doing homework/study with computer (ICC = .54*; kappa = .53**), doing homework/study without computer (ICC = .50*; kappa = .47**), reading for fun (ICC = .69*; kappa = .64**), nonscreen sedentary time—social (ICC = .67*), sitting and talking (ICC = .46*; kappa = .39**), listening to music (ICC = .68*; kappa = .61**), talking on the telephone (ICC = .77*; kappa = .70**), nonscreen sedentary time—others (ICC = .58*); sitting to rest (ICC = .52*; kappa = .51**), doing cognitive hobbies (ICC = .55*; kappa = .50**), traveling on motorized transport (ICC = .56*; kappa = .49**); average day: total sedentary time (ICC = .76*), screen time (ICC = .77*), watching TV/videos (ICC = .75*), playing computer/video games (ICC = .60*), internet surfing (ICC = .75*), nonscreen sedentary time—educational (ICC = .71*), doing homework/study with computer (ICC = .66*), doing homework/study without computer (ICC = .61*), reading for fun (ICC = .82*), nonscreen sedentary time—social (ICC = .72*), sitting and talking (ICC = .40*), listening to music (ICC = .66*), talking on the telephone (ICC = .82*), nonscreen sedentary time—others (ICC = .63*), sitting to rest (ICC = .50*), doing cognitive hobbies (ICC = .54*), traveling on motorized transport (ICC = .66*)		–
Sleep CCTQ ⁶⁹	43; N.R.; 4–11 y	20 d	Sleep period (weekdays) ($r = .94$); sleep period (weekend days) ($r = .79$); time of lights-off (weekdays) ($r = .90$); time of lights-off (weekend days) ($r = .85$); sleep onset (weekdays) ($r = .92$); sleep onset (weekend days) ($r = .89$); wake-up time (weekdays) ($r = .89$); wake-up time (weekend days) ($r = .91$)		+
PA + SB GAQ ⁷⁰	67; 100% girls; 8–9 y	4 d	28 activities—past day ($r = .78$ **); 18 activities—past day ($r = .70$ **); TV watching—past day ($r = .35$ **); other sedentary—past day ($r = .47$ **); 28 activities—usual day ($r = .82$ **); 18 activities—usual day ($r = .79$ **); TV watching—usual day ($r = .28$ **); other sedentary—usual day ($r = .48$ **)		–
ENERGY-C Q ⁷¹	730; N.R.; 10–12 y	1 wk	Bike to school (d/wk) (ICC = .94; %agreement = 73%); bike to school (min/d) (ICC = .81; %agreement = 85%); walk to school (d/wk) (ICC = .91; %agreement = 81%); walk to school (min/d) (ICC = .70; %agreement = 70%); car to school (d/wk) (ICC = .91; %agreement = 84%); public transport to school (d/wk) (ICC = .88; %agreement = 96%), first sport (h/wk) (ICC = .74; %agreement = 55%); second sport (h/wk) (ICC = 1.00; %agreement = 43%); sport past day (h/wk) (ICC = .22; %agreement = 28%); computer use in free time (h/weekday) (ICC = .67; %agreement = 41%); computer use in free time (h/weekend days) (ICC = .65; %agreement = 38%); TV (h/past day) (ICC = .68; %agreement = 36%); computer use in free time (h/past day) (ICC = .54; %agreement = 51%)		–
IPAQ ⁵⁵	71; 56.3% girls; 13–18 y	8–12 d	VPA d/wk (ICC = .54); VPA min/d (ICC = .30); MPA d/wk (ICC = .55); MPA min/d (ICC = .34); walking d/wk (ICC = .62); walking min/d (ICC = .10); sitting min/d (ICC = .27)		–
SHAPES ⁷²	460; N.R.; N.R.	1 wk	Weekly VPA (h) (kappa = .40); weekly MPA (h) (kappa = .33); weekly MVPA (h) (kappa = .37); weekly screen time (h) (kappa = .51); PA level (inactive, moderately active, active) (kappa = .58)		–

(continued)

Table 3 (continued)

Questionnaire	Sample		Reliability		Overall quality
	n; %girls; age mean (SD) or age range, y	Time between test and retest	Results		
MARCA ⁷³	37; 44% girls; 9–13 y	Same day (285 min)	PA level (ICC = .93); MVPA min (ICC = .94); locomotion min (ICC = .88; SEM = 0.26.1; upper LoA = 79.2; lower LoA = -65.4) Measurement error: PA level (SEM = 0.11; upper LoA = 0.3; lower LoA = -0.30; bias = +0.001); MVPA (SEM = 18.9; upper LoA = 51.2; lower LoA = -53.4; bias = -1.1); locomotion (SEM = 0.26.1; upper LoA = 79.2; lower LoA = -65.4; bias = +6.9) MVPA (ICC = .69) Activity (rho = 0.78***); sedentary (rho = 0.38*) Watching TV/video/DVD (rho = 0.60*); sitting at a computer/playing Nintendo/electronic games (ICC = .61*); doing homework (ICC = .56*); reading (ICC = .64*); playing a musical instrument (ICC = .34*); playing quietly/other quiet activities (ICC = .42*); traveling by car/public transport (ICC = .49*); playing vigorously active indoors (ICC = .41*); playing vigorously active outdoors (ICC = .43*); cycling (ICC = .64*)		+
peas@tees ⁷⁴	42; 48% girls; N.R.	2 d			-
HSK ⁷⁵	35; N.R.; 9–14 y	8 wk			-
PQPASB ⁷⁶	125; 53% girls; 6–10 and 13–14 y	2 wk			-
PA + SB + sleep					
Daughter Questionnaire ⁷⁷	69 girls; 8.5–12.7 y	12–16 d	School day: sleeping (ICC = .51), sitting (ICC = .35), standing/light (ICC = .28), walking/moderate (ICC = .48), exercising/vigorous (ICC = .36), TV/VCR/video games (ICC = .84); weekend day: sleeping (ICC = .68); sitting (ICC = .36); standing/light (ICC = .43); walking/moderate (ICC = .32); exercising/vigorous (ICC = .32); TV/VCR/video games (ICC = .81)		-
Mother and Father Questionnaires ⁷⁷	69 girls; 8.5–12.7 y	12–28 d	Mothers, school day: sleeping (ICC = .66), sitting (ICC = .21), standing/light (ICC = .11), walking/moderate (ICC = .28), exercising/vigorous (ICC = .72), TV/VCR/video games (ICC = .45); mothers, weekend day: sleeping (ICC = .71), sitting (ICC = .25), standing/light (ICC = .32), walking/moderate (ICC = .33), exercising/vigorous (ICC = .65), TV/VCR/video games (ICC = .82); fathers, school day: sleeping (ICC = .14), sitting (ICC = .20), standing/light (ICC = .32), walking/moderate (ICC = .24), exercising/vigorous (ICC = .75), TV/VCR/video games (ICC = .86); fathers, weekend day: sleeping (ICC = .05), sitting (ICC = .24), standing/light (ICC = .12); walking/moderate (ICC = .13), exercising/vigorous (ICC = .72), TV/VCR/video games (ICC = .79)		-

Abbreviations: -, inadequate; +, adequate; ?, doubtful; 3DPAR, 3-d Physical Activity Recall; APARQ, Adolescent Physical Activity Recall Questionnaire; CCTQ, Children's Chronotype Questionnaire; CLASS—Proxy and self; The Children's Leisure Activities Study Survey—Proxy; The Children's Leisure Activities Study Survey—Proxy; cPAQ, computer-based physical activity questionnaire; D, duration; EAQOT-SB, Eating and Activity Questionnaire Trial—Sedentary Behavior questions; ENERGY-C Q, ENERGY-Child Questionnaire; Fels PAQ, Fels Physical Activity Questionnaire; GEMIS Activity Questionnaire; HBSC PAQ, Health Behavior in Schoolchildren Physical Activity Questionnaire; Helena SB Q, HELENA screen time-based sedentary behavior questionnaire; HPAQ, Habitual Physical Activity Questionnaire; HSK, Heart Smart Kids; ICC, intraclass correlation coefficient; IPAQ, International Physical Activity Questionnaire; LoA, limits of agreement; LPA, light physical activity; MARCA, multimedia activity recall for children and adolescents; MGLTEQ, Modified Godin-Leisure-Time Exercise Questionnaire; MoMo, MoMo-Physical-Activity-Questionnaire for Adolescents; MPA and VPA S Q, moderate and Vigorous Physical Activity Screening Questionnaire; MPA, Moderate Physical Activity; MVPA, moderate to vigorous physical activity; n, sample number; NA, not applicable; NR., not reported; NSST, nonscreen sedentary time; O-O-S PAQ, Out-of-School Physical Activity Questionnaire; OPAQ, Oxford Physical Activity Questionnaire; PA, physical activity; PACE + PAM, PACE + Adolescent Physical Activity Measure; PAL, physical activity level; PQPASB, Parental Questionnaire for Physical Activity and Sedentary Behavior; PYPAA, past year physical activity in adolescents; SAPAC, Self-Administered Physical Activity Checklist; SAYCARE PA Q A, SAYCARE Physical Activity Questionnaire for adolescents; SAYCARE PA Q C, SAYCARE Physical Activity Questionnaire for children; SAYCARE SB Q A, South American Youth Cardiovascular and Environmental sedentary behavior questionnaire for adolescents; SAYCARE SB Q C, SAYCARE South American Youth Cardiovascular and Environmental sedentary behavior questionnaire for children; SB, sedentary behavior; SHAPES, School Health Action, Planning and Evaluation System; S-I PA M, single-item physical activity measure; SIT-Q-7d, last-7-d sedentary behavior questionnaire; VIC, vigorous; VPA, vigorous physical activity; YLSBQ, Youth Leisure-time Sedentary Behavior Questionnaire; YRBS, Youth Risk Behavior Survey.

Table 4 Summary of Results

Questionnaire	Validity quality		Reliability quality	Content validity quality	Risk of bias		
	Criterion	Convergent			Validity		Reliability
					Criterion	Convergent	
PA							
CLASS—Proxy ³⁰	–	NA	+	CD	1	NA	1
SAYCARE PA Q C ⁵⁰	–	NA	–	+	1	NA	3
O-O-S PAQ ⁵¹	–	NA	–	+	1	NA	2
HPAQ ⁵²	NA	–/–/–/–	–	–	1	4	2
3DPAR ⁵³	–/–	NA	–	+	1	NA	3
YRBS ⁵⁴	–	NA	–	+	1	NA	4
SAPAC ⁵³	–/–	NA	–	CD	1	NA	3
HBSC PAQ ⁵⁵	–/–	–	+	–	1	4	4
MGLTEQ ⁵⁶	–	NA	–	–	1	NA	3
OPAQ ⁵⁷	–	NA	+	+	1	NA	3
APARQ ⁵⁸	NA	–	–	+	NA	4	1
PYPAA ⁵⁹	NA	–/–/–/–/–/–/–/–	–	–	NA	4	3
cPAQ ⁶⁰	NA	+	–	CD	NA	2	1
S-I PA M ⁶¹	–	NA	+	+	1	NA	2
MPA and VPA S Q ⁵⁴	–	NA	–	+	1	NA	2
PACE + PAM ⁵⁴	–	NA	+	+	1	NA	3
SAYCARE PA Q A ⁵⁰	–	NA	–	+	1	NA	3
CLASS—Proxy and self ³⁰	–	NA	–	CD	1	NA	1
Fels PAQ ⁶²	–	NA	–	–	1	NA	2
MoMo ⁶³	–	NA	–	–	1	NA	1
SB							
SAYCARE SB Q C ⁶⁴	–	NA	–	+	1	NA	3
EAQT-SB ⁶⁵	NA	–	–	–	NA	4	3
Helena SB Q ⁶⁶		NA	+	–	4	NA	1
SIT-Q-7d ⁶⁷	–	NA	–	+	1	NA	2
SAYCARE SB Q A ⁶⁴	–	NA	–	+	1	NA	3
YLSBQ ⁶⁸	–	NA	–	–	1	NA	1
Sleep							
CCTQ ⁶⁹	+	NA	+	+	4	NA	3
PA + SB							
GAQ ⁷⁰	–	NA	–	–	1	NA	3
ENERGY-C Q ⁷¹	NA	–	–	+	NA	4	1
IPAQ ⁵⁵	–/–	–	–	+	1	4	4
SHAPES ⁷²	–	NA	–	+	1	NA	1
MARCA ⁷³	–	NA	+	+	1	NA	3
peas@tees ⁷⁴	–	NA	–	+	1	NA	1
HSK ⁷⁵	–	NA	–	+	NA	4	3
PQPASB ⁷⁶	–	NA	–	+	1	NA	3

(continued)

Table 4 (continued)

Questionnaire	Validity quality		Reliability quality	Content validity quality	Risk of bias		
	Criterion	Convergent			Validity		
					Criterion	Convergent	Reliability
PA + SB + sleep							
Daughter Questionnaire ⁷⁷	NA	–	–	CD	NA	3	1
Mother and Father Questionnaires ⁷⁷	NA	–	–	CD	NA	3	3

Abbreviations: –, inadequate; +, adequate; ?, doubtful; 3DPAR, 3-d Physical Activity Recall; APARQ, Adolescent Physical Activity Recall Questionnaire; CCTQ, Children's ChronoType Questionnaire; CD, cannot be determined; CLASS—Proxy and self, The Children's Leisure Activities Study Survey—Proxy and self-reported; CLASS—Proxy, The Children's Leisure Activities Study Survey—Proxy; cPAQ, computer-based physical activity questionnaire; EAQT-SB, Eating and Activity Questionnaire Trial—Sedentary Behavior questions; ENERGY-C Q, ENERGY-Child Questionnaire; Fels PAQ, Fels Physical Activity Questionnaire; GAQ, GEMS Activity Questionnaire; HBSC PAQ, Health Behavior in Schoolchildren Physical Activity Questionnaire; Helena SB Q, HELENA screen time-based sedentary behavior questionnaire; HPAQ, Habitual Physical Activity Questionnaire; HSK, Heart Smart Kids; IPAQ, International Physical Activity Questionnaire; LPA, light physical activity level; MARCA, multimedia activity recall for children and adolescents; MGLTEQ, Modified Godin-Leisure-Time Exercise Questionnaire; MoMo, MoMo-Physical-Activity-Questionnaire for Adolescents; MPA and VPA S Q, moderate and Vigorous Physical Activity Screening Questionnaire; MPA, Moderate Physical Activity; MVPA, moderate to vigorous physical activity; n, sample number; NA, not applicable; NSST, nonscreen sedentary time; O-O-S PAQ, Out-of-School Physical Activity Questionnaire; OPAQ, Oxford Physical Activity Questionnaire; PA, physical activity; PACE + PAM, PACE + Adolescent Physical Activity Measure; PAL, physical activity level; PQPASB, Parental Questionnaire for Physical Activity and Sedentary Behavior; PYPAA, past year physical activity in adolescents; SAPAC, Self-Administered Physical Activity Checklist; SAYCARE PA Q A, SAYCARE Physical Activity Questionnaire for adolescents; SAYCARE PA Q C, SAYCARE Physical Activity Questionnaire for children; SAYCARE SB Q A, South American Youth Cardiovascular and Environmental sedentary behavior questionnaire for adolescents; SAYCARE SB Q C, South American Youth Cardiovascular and Environmental sedentary behavior questionnaire for Children; SB, sedentary behavior; SHAPES, School Health Action, Planning and Evaluation System; S-I PA M, single-item physical activity measure; SIT-Q-7d, last-7-d sedentary behavior questionnaire; VPA, vigorous physical activity; YLSBQ, Youth Leisure-time Sedentary Behavior Questionnaire; YRBS, Youth Risk Behavior Survey. Note: 1, very low risk of bias; 2, low risk of bias; 3, medium risk of bias; 4, high risk of bias.

an integrated fashion. These will allow researchers, public health professionals, and policy makers to push forward the (1) monitoring of 24-hour movement behaviors, (2) assessing 24-hour movement guidelines compliance, (3) analyzing the health-related associations of movement behaviors combinations, and (4) promoting the healthy 24-hour movement behaviors. The same concern has been raised with the launch of the new World Health Organization PA and SB guidelines for adults.⁸¹

Limitations and Strengths

This review described and appraised questionnaires' content and measurement properties following the best practices proposed by the COSMIN guidelines, which is a strength of our work. The eligibility criterion (eg, minimum of 50 participants for validity studies; inclusion of questionnaires with both validity and reliability) is another strength of our work, as it excluded questionnaires with specific methodological shortcomings or with incomplete validation processes. Using the cutoff points proposed by COSMIN to evaluate the quality of measurement properties elevated the demanding of the appraisal of content and measurement properties of the included questionnaires. Also, to the best of our knowledge, this review comprises the largest number of questionnaires assessing movement behaviors, in children and adolescents, including an extensive description of the questionnaires' content.

In terms of limitations, comparing questionnaires' measurement properties is complex, mainly due to the diversity of the methodologies and results, including different domains, scores, recall periods, comparison measures, reporting units, and statistics. The use of the COSMIN guidelines may have led, at least in part, to loss of information and dichotomization (eg, adequate or inadequate) due to the mechanistic way of analyzing the data. For example, a given questionnaire may be classified as having an overall "inadequate" validity; however, the questionnaire might be appropriate to apply when the intention aim is to evaluate specific constructs from the items with "adequate" validity scores. Finally, as we followed an

adaptation of the COSMIN guidelines and other reviews have followed other assumptions and guidelines with different cutoffs, direct comparisons between reviews should be carefully done.

Conclusion

The questionnaires included in this review showed considerable diversity in content and, for the most part, inadequate validity and reliability scores. Existing questionnaires have insufficient measurement properties, and none were developed considering the 24-hour movement behavior paradigm. These results emphasize the intricacy of assessing movement behaviors in isolation and in combination and highlight the need for better questionnaires measuring each movement behavior and new questionnaires to measure 24-hour movement behavior combinations. Additionally, the existence of 24-hour movement guidelines raises the need to adapt or develop *de novo* self- and proxy-reported measures to assess 24-hour movement behavior levels and patterns, as well as guidelines compliance, in children and adolescents.

The current review confirms previous systematic reviews' findings showing that most questionnaires have insufficient measurement properties and extends it to questionnaires assessing more than one movement behavior. Based on our results regarding the included questionnaires' measurement properties and content, we cannot recommend one or a set of questionnaires to accurately measure children and adolescents' movement behaviors, considering the new 24-hour movement paradigm in youth.

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5.2. Supplementary work

5.2.1. Supplementary work 1 – PICO's Strategy

Population:

Children and adolescents (aged less than 17.9 years);

Intervention (Exposure):

Development, validation, and reliability studies of self- and proxy reports questionnaires that measure physical activity, sedentary behaviour or sleep.

Description of the questionnaires' content and measurement properties.

Comparator:

N.A.

Outcomes:

Content analysis:

1. Mode of administration;
2. Domains;
3. Response method;
4. Units of measurement;
5. Scores;
6. Recall Period/Assessment period
7. Number de items
8. Parameters

Measurement properties:

General characteristics of the studies:

1. Study population: gender, age and country;
2. Study design: sample size and time interval between administrations;
3. Administration mode;
4. Other instruments used for validation.

Measurement properties of the studies:

5. Validity properties;
6. Reliability properties;
7. Responsiveness.

5.2.2. Supplementary work 2 – Search Strategy

PubMed

("early childhood" OR child OR preschool OR preschooler OR preschoolers OR children OR childhood OR childcares OR adolescence OR adolescents OR adolescent OR youth OR teen OR teen OR teenagers OR teenaged OR teenage OR teeners OR teener OR teenager OR Infant OR pediatric OR paediatric OR toddlers* OR young* OR junior OR baby OR kid OR kids OR infanthood OR babies OR Adolescent [Mesh] OR Child [Mesh] OR Infant [Mesh])

AND

(exercise[Mesh] OR exercise [Title/Abstract] OR "physical activity" [Title/Abstract] OR "physical activities" [Title/Abstract] OR "sedentary behavior" [Mesh] OR "sedentary behavior" [Title/Abstract] OR "sedentary behaviors" [Title/Abstract] OR "sedentary behaviour" [Title/Abstract] OR "sedentary behaviours" [Title/Abstract] OR "sitting position" [Mesh] OR "screen time" [Mesh] OR sedentar* [Title/Abstract] OR sleep [Mesh] OR sleep [Title/Abstract] OR "movement behavior*" [Title/Abstract] OR "movement behaviou*" [Title/Abstract] OR inactiv* [Title/Abstract])

AND

(instrumentation[sh] OR methods[sh] OR "Validation Studies"[pt] OR "Comparative Study"[pt] OR "psychometrics"[MeSH] OR psychometr*[tiab] OR clinimetr*[tw] OR clinometr*[tw] OR "outcome assessment (health care)"[MeSH] OR "outcome assessment"[tiab] OR "outcome measure*" [tw] OR "observer variation"[MeSH] OR "observer variation"[tiab] OR "Health Status Indicators"[Mesh] OR "reproducibility of results"[MeSH] OR reproducib*[tiab] OR "discriminant analysis"[MeSH] OR reliab*[tiab] OR unreliab*[tiab] OR valid*[tiab] OR "coefficient of variation"[tiab] OR coefficient[tiab] OR homogeneity[tiab] OR homogeneous[tiab] OR "internal consistency"[tiab] OR (cronbach*[tiab] AND (alpha[tiab] OR alphas[tiab])) OR (item[tiab] AND (correlation*[tiab] OR selection*[tiab] OR reduction*[tiab])) OR agreement[tw] OR precision[tw] OR imprecision[tw] OR "precise values"[tw] OR test-retest[tiab] OR (test[tiab] AND retest[tiab]) OR (reliab*[tiab] AND (test[tiab] OR retest[tiab])) OR stability[tiab] OR interrater[tiab] OR inter-rater[tiab] OR intrarater[tiab] OR intra-rater[tiab] OR intertester[tiab] OR inter-tester[tiab] OR intratester[tiab] OR intra-tester[tiab] OR interobserver[tiab] OR inter-observer[tiab] OR intraobserver[tiab] OR intra-observer[tiab] OR

intertechnician[tiab] OR inter-technician[tiab] OR intratechnician[tiab] OR intra-technician[tiab] OR interexaminer[tiab] OR inter-examiner[tiab] OR intraexaminer[tiab] OR intra-examiner[tiab] OR interassay[tiab] OR inter-assay[tiab] OR intraassay[tiab] OR intra-assay[tiab] OR interindividual[tiab] OR inter-individual[tiab] OR intraindividual[tiab] OR intra-individual[tiab] OR interparticipant[tiab] OR inter-participant[tiab] OR intraparticipant[tiab] OR intra-participant[tiab] OR kappa[tiab] OR kappa's[tiab] OR kappas[tiab] OR repeatab*[tw] OR ((replicab*[tw] OR repeated[tw]) AND (measure[tw] OR measures[tw] OR findings[tw] OR result[tw] OR results[tw] OR test[tw] OR tests[tw])) OR generaliza*[tiab] OR generalisa*[tiab] OR concordance[tiab] OR (intraclass[tiab] AND correlation*[tiab]) OR discriminative[tiab] OR "known group"[tiab] OR "factor analysis"[tiab] OR "factor analyses"[tiab] OR "factor structure"[tiab] OR "factor structures"[tiab] OR dimension*[tiab] OR subscale*[tiab] OR (multitrait[tiab] AND scaling[tiab] AND (analysis[tiab] OR analyses[tiab])) OR "item discriminant"[tiab] OR "interscale correlation*" [tiab] OR error[tiab] OR errors[tiab] OR "individual variability"[tiab] OR "interval variability"[tiab] OR "rate variability"[tiab] OR (variability[tiab] AND (analysis[tiab] OR values[tiab])) OR (uncertainty[tiab] AND (measurement[tiab] OR measuring[tiab])) OR "standard error of measurement"[tiab] OR sensitiv*[tiab] OR responsive*[tiab] OR (limit[tiab] AND detection[tiab]) OR "minimal detectable concentration"[tiab] OR interpretab*[tiab] OR ((minimal[tiab] OR minimally[tiab] OR clinical[tiab] OR clinically[tiab]) AND (important[tiab] OR significant[tiab] OR detectable[tiab]) AND (change[tiab] OR difference[tiab])) OR (small*[tiab] AND (real[tiab] OR detectable[tiab]) AND (change[tiab] OR difference[tiab])) OR "meaningful change"[tiab] OR "ceiling effect"[tiab] OR "floor effect"[tiab] OR "Item response model"[tiab] OR IRT[tiab] OR Rasch[tiab] OR "Differential item functioning"[tiab] OR DIF[tiab] OR "computer adaptive testing"[tiab] OR "item bank"[tiab] OR "cross-cultural equivalence"[tiab])

PsycInfo

("early childhood" OR child OR preschool OR preschooler OR preschoolers OR children OR childhood OR childcares OR adolescence OR adolescents OR adolescent OR youth OR teen OR teen OR teenagers OR teenaged OR teenage OR teeners OR teener OR teenager OR Infant OR pediatric OR paediatric OR toddlers* OR young* OR junior OR baby OR kid OR kids OR infanthood OR babies)

AND

(exercise OR "physical activity" OR "physical activities" OR "sedentary

behavior OR "sedentary behaviors" OR "sedentary behaviour" OR "sedentary behaviours" OR "sitting position" OR "screen time" OR sedentar* OR sleep OR "movement behavio*" OR "movement behaviou*" OR inactiv* OR bedtime OR bedtime* OR "time in bed")

AND

(surveys OR survey OR surveillance OR questionnaire OR questionnaires OR "proxy-reported" OR "proxy-report" OR "proxy-reports" OR "proxy report" OR "proxy reported" OR instrument OR instruments OR measur* OR scale OR scales OR assess* OR tool OR tools OR Interview* OR "self-report" OR "self-reported" OR "self-reports" OR "self report" OR "self reported" [Title/Abstract])

AND

("psychometrics" OR psychometr* OR clinimetr* OR clinometr* OR "outcome assessment" OR "outcome measure*" OR "observer variation" OR "observer variation" OR "Health Status Indicators" OR "reproducibility of results" OR reproducib* OR "discriminant analysis" OR reliab* OR unreliab* OR valid* OR "coefficient of variation" OR coefficient OR homogeneity OR homogeneous OR "internal consistency" OR (cronbach* AND (alpha OR alphas)) OR (item AND (correlation* OR selection* OR reduction*)) OR agreement OR precision OR imprecision OR "precise values" OR test-retest OR (test AND retest) OR (reliab* AND (test OR retest)) OR stability OR interrater OR inter-rater OR intrarater OR intra-rater OR intertester OR inter-tester OR intratester[tiab] OR intra-tester OR interobserver OR inter-observer OR intraobserver OR intra-observer OR intertechnician OR inter-technician OR intratechnician OR intra-technician OR interexaminer OR inter-examiner OR intraexaminer OR intra-examiner OR interassay OR inter-assay OR intraassay OR intra-assay OR interindividual OR inter-individual OR intraindividual OR intra-individual OR interparticipant OR inter-participant OR intraparticipant OR intra-participant OR kappa OR kappa's OR kappas OR repeatab* OR ((replicab* OR repeated) AND (measure OR measures OR findings OR result OR results OR test OR tests)) OR generaliza* OR generalisa* OR concordance OR (intraclass AND correlation*) OR discriminative OR "known group" OR "factor analysis" OR "factor analyses" OR "factor structure" OR "factor structures" OR dimension* OR subscale* OR (multitrait AND scaling AND (analysis OR analyses)) OR "item discriminant" OR "interscale correlation*" OR error OR errors OR "individual variability" OR "interval variability"

OR "rate variability" OR (variability AND (analysis OR values)) OR (uncertainty AND (measurement OR measuring)) OR "standard error of measurement" OR sensitiv* OR responsive* OR (limit AND detection) OR "minimal detectable concentration" OR interpretab* OR ((minimal OR minimally OR clinical OR clinically) AND (important OR significant OR detectable) AND (change OR difference)) OR (small* AND (real OR detectable) AND (change OR difference)) OR "meaningful change" OR "ceiling effect" OR "floor effect" OR "Item response model" OR IRT OR Rasch OR "Differential item functioning" OR DIF OR "computer adaptive testing" OR "item bank" OR "cross-cultural equivalence")

EMBASE

("early childhood" OR child OR preschool OR preschooler OR preschoolers OR children OR childhood OR childcares OR adolescence OR adolescents OR adolescent OR youth OR teen OR teen OR teenagers OR teenaged OR teenage OR teeners OR teener OR teenager OR Infant OR pediatric OR paediatric OR toddlers* OR young* OR junior OR baby OR kid OR kids OR infanthood OR babies)

AND

(exercise OR "physical activity" OR "physical activities" OR "sedentary behavior" OR "sedentary behaviors" OR "sedentary behaviour" OR "sedentary behaviours" OR "sitting position" OR "screen time" OR sedentar* OR sleep OR "movement behavior*" OR "movement behaviour*" [Title/Abstract] OR inactiv* OR bedtime OR bedtime* OR "time in bed")

AND

(surveys OR survey OR surveillance OR questionnaire OR questionnaires OR "proxy-reported" OR "proxy-report" OR "proxy-reports" OR "proxy report" OR "proxy reported" OR instrument OR instruments OR measur* OR scale OR scales OR assess* OR tool OR tools OR Interview* OR "self-report" OR "self-reported" OR "self-reports" OR "self report" OR "self reported" [Title/Abstract])

AND

("psychometrics" OR psychometr* OR clinimetr* OR clinometr* OR "outcome assessment" OR "outcome measure*" OR "observer variation" OR "observer variation" OR "Health Status Indicators"

OR "reproducibility of results" OR reproducib* OR "discriminant analysis" OR reliab* OR unreliab* OR valid* OR "coefficient of variation" OR coefficient OR homogeneity OR homogeneous OR "internal consistency" OR (cronbach* AND (alpha OR alphas)) OR (item AND (correlation* OR selection* OR reduction*)) OR agreement OR precision OR imprecision OR "precise values" OR test-retest OR (test AND retest) OR (reliab* AND (test OR retest)) OR stability OR interrater OR inter-rater OR intrarater OR intra-rater OR intertester OR inter-tester OR intratester[tiab] OR intra-tester OR interobserver OR inter-observer OR intraobserver OR intra-observer OR intertechnician OR inter-technician OR intratechnician OR intra-technician OR interexaminer OR inter-examiner OR intraexaminer OR intra-examiner OR interassay OR inter-assay OR intraassay OR intra-assay OR interindividual OR inter-individual OR intraindividual OR intra-individual OR interparticipant OR inter-participant OR intraparticipant OR intra-participant OR kappa OR kappa's OR kappas OR repeatab* OR ((replicab* OR repeated) AND (measure OR measures OR findings OR result OR results OR test OR tests)) OR generaliza* OR generalisa* OR concordance OR (intraclass AND correlation*) OR discriminative OR "known group" OR "factor analysis" OR "factor analyses" OR "factor structure" OR "factor structures" OR dimension* OR subscale* OR (multitrait AND scaling AND (analysis OR analyses)) OR "item discriminant" OR "interscale correlation*" OR error OR errors OR "individual variability" OR "interval variability" OR "rate variability" OR (variability AND (analysis OR values)) OR (uncertainty AND (measurement OR measuring)) OR "standard error of measurement" OR sensitiv* OR responsive* OR (limit AND detection) OR "minimal detectable concentration" OR interpretab* OR ((minimal OR minimally OR clinical OR clinically) AND (important OR significant OR detectable) AND (change OR difference)) OR (small* AND (real OR detectable) AND (change OR difference)) OR "meaningful change" OR "ceiling effect" OR "floor effect" OR "Item response model" OR IRT OR Rasch OR "Differential item functioning" OR DIF OR "computer adaptive testing" OR "item bank" OR "cross-cultural equivalence")

SportDiscus

("early childhood" OR child OR preschool OR preschooler OR preschoolers OR children OR childhood OR childcares OR adolescence OR adolescents OR adolescent OR youth OR teen OR teen OR teenagers OR teenaged OR teenage OR teeners OR teener OR teenager OR Infant OR pediatric OR paediatric OR toddlers* OR young* OR junior OR baby OR kid OR kids OR

infanthood OR babies)

AND

(exercise OR "physical activity" OR "physical activities" OR "sedentary behavior OR "sedentary behaviors" OR "sedentary behaviour" OR "sedentary behaviours" OR "sitting position" OR "screen time" OR sedentar* OR sleep OR "movement behavio*" OR "movement behaviou*" [Title/Abstract] OR inactiv* OR bedtime OR bedtime* OR "time in bed")

AND

(surveys OR survey OR surveillance OR questionnaire OR questionnaires OR "proxy-reported" OR "proxy-report" OR "proxy-reports" OR "proxy report" OR "proxy reported" OR instrument OR instruments OR measur* OR scale OR scales OR assess* OR tool OR tools OR Interview* OR "self-report" OR "self-reported" OR "self-reports" OR "self report" OR "self reported" [Title/Abstract])

AND

("psychometrics" OR psychometr* OR clinimetr* OR clinometr* OR "outcome assessment" OR "outcome measure*" OR "observer variation" OR "observer variation" OR "Health Status Indicators" OR "reproducibility of results" OR reproducib* OR "discriminant analysis" OR reliab* OR unreliab* OR valid* OR "coefficient of variation" OR coefficient OR homogeneity OR homogeneous OR "internal consistency" OR (cronbach* AND (alpha OR alphas)) OR (item AND (correlation* OR selection* OR reduction*)) OR agreement OR precision OR imprecision OR "precise values" OR test-retest OR (test AND retest) OR (reliab* AND (test OR retest)) OR stability OR interrater OR inter-rater OR intrarater OR intra-rater OR intertester OR inter-tester OR intratester[tiab] OR intra-tester OR interobserver OR inter-observer OR intraobserver OR intra-observer OR intertechnician OR inter-technician OR intratechnician OR intra-technician OR interexaminer OR inter-examiner OR intraexaminer OR intra-examiner OR interassay OR inter-assay OR intraassay OR intra-assay OR interindividual OR inter-individual OR intraindividual OR intra-individual OR interparticipant OR inter-participant OR intraparticipant OR intra-participant OR kappa OR kappa's OR kappas OR repeatab* OR ((replicab* OR repeated) AND (measure OR measures OR findings OR result OR results OR test OR tests)) OR generaliza* OR generalisa* OR concordance OR (intraclass AND correlation*) OR discriminative OR "known group" OR "factor analysis" OR

“factor analyses” OR “factor structure” OR “factor
 structures” OR dimension*OR subscale* OR (multitrait AND scaling AND
 (analysis OR analyses)) OR “item
 discriminant” OR “interscale correlation*” OR error OR errors OR “individual
 variability” OR “interval variability”
 OR “rate variability” OR (variability AND (analysis OR values)) OR (uncertainty
 AND (measurement OR
 measuring)) OR “standard error of measurement” OR sensitiv* OR responsive*
 OR (limit AND detection) OR
 “minimal detectable concentration” OR interpretab* OR ((minimal OR
 minimally OR clinical OR clinically) AND (important OR significant OR
 detectable) AND (change OR difference)) OR (small* AND (real OR
 detectable) AND (change OR difference)) OR “meaningful change” OR
 “ceiling effect” OR “floor effect” OR “Item response model” OR IRT OR Rasch
 OR “Differential item functioning” OR DIF OR “computer adaptive testing” OR
 “item bank” OR “cross-cultural equivalence”)

5.2.3. Supplementary work 3 – Extracted Information

For **content description**, we extracted information about:

- 1- Name of the questionnaire:
- 2- Age group and country: If the questionnaire was validated in children, adolescents, or both.
- 3- Domains: Which domains the questionnaire refers to (e.g., leisure, occupational, transportation, etc.). When there was no distinction between domains, we reported total sleep/ sedentary behaviour/physical activity.
- 4- Response method: What kind of response the questionnaire allows for (e.g., rating scale or continuous response).
- 5- Measurement units: Which unit the researchers must use to evaluate the movement behaviours (e.g., METs, minutes/day; hours/week, etc.).
- 6- Scores: What are the final outputs from the questionnaire (e.g., total sleep/ sedentary behaviour/physical activity; sleep duration; occupational physical activity/ sedentary behaviour, activity level index, etc.).
- 7- Recall period/Assessment period: To which period the questionnaire refers to (e.g., typical/last day/week, on week and weekend or whole day/week without distinction for the types of days, etc.);
- 8- Number of items: How many items compose the questionnaire.
- 9- Parameters: Frequency, duration, intensity and mode.

For **measurement properties**, we extracted information about:

- 1- Sample size and demographic characteristics (e.g., gender and age).
- 2- **Validity**: The degree to which an instrument truly measures the construct(s) that wants to measure, free from all possible sources of error or bias.

- a. Type of validity: Criterion (e.g., the extent of the correlation between a measure and another already considered as being a criterion or gold standard) or convergent (e.g., the extent of the agreement with another (non-criterion) measure that should assess the same behaviour parameter based on face and content validity).
- b. Comparison measure: Which instrument was used to validation (e.g., accelerometer, another questionnaire, etc.). Results
- c. Validity results per variable (e.g., Pearson/Spearman correlations, Bland Altman, etc.).

3.1 – Quality of study: Explained below.

3- Reliability

- d. Time between test and retest.
- e. Results: Pearson and Spearman correlations, intraclass correlations, Kappa's, measurement error (e.g., limits of agreement, etc.).

4- Responsiveness:

- a. Type of responsiveness.
- b. Results: Effect tests, etc

5.2.4. Supplementary work 4 – Content Validity

Table S1. Content Validity Results

Questionnaire	1.Questionnaire integrated in paper?	2.Did we find the questionnaire in other source? Where?	3.At least 85% of the items are relevant for the construct of interest.	4.At least 85% of the items are relevant for the population of interest.	5.At least 85% of the items are relevant for the context of use of interest.	6.At least 85% of the response options are appropriate for the construct, population, and context of use of interest.	7.The recall period is appropriate for the construct, population, and context of use of interest.	8.The questionnaire is comprehensive for the construct, population and context of use of interest.	9.At least 85% of the items and response options are appropriately worded.	10.At least 85% of the response options match the questions.	Overall Rating
Physical Activity											
The Children's Leisure Activities Study Survey - Proxy (CLASS - Proxy) ²⁵	No	No									
SAYCARE Physical Activity Questionnaire for children (SAYCARE PA Q C) ⁴⁷	No	Yes, sent by authors	+	+	+	+	+	+	+	+	+
Out-of-school physical activity questionnaire (O-O-S PAQ) ⁴⁸	Yes	NA	+	+	+	-	+	+	+	+	+
Habitual Physical Activity Questionnaire (HPAQ) ⁴⁹	Yes	NA	-	-	-	+	+	+	+	+	-
3-Day Physical Activity Recall (3DPAR) ⁵⁰	No	No, Waiting									

Questionnaire	1.Questionnaire integrated in paper?	2.Did we find the questionnaire in other source? Where?	3.At least 85% of the items are relevant for the construct of interest.	4.At least 85% of the items are relevant for the population of interest.	5.At least 85% of the items are relevant for the context of use of interest.	6.At least 85% of the response options are appropriate for the construct, population, and context of use of interest.	7.The recall period is appropriate for the construct, population, and context of use of interest.	8.The questionnaire is comprehensive for the construct, population and context of use of interest.	9.At least 85% of the items and response options are appropriately worded.	10.At least 85% of the response options match the questions.	Overall Rating
Youth Risk Behavior Survey (YRBS) ⁵¹	Yes	Yes, CDC site	+	+	+	+	+	+	+	+	+
Self-Administered Physical Activity Checklist (SAPAC) ⁵⁰	No	No									
Health Behaviour in Schoolchildren Physical Activity Questionnaire (HBSC PAQ) ⁵²	Yes	NA	+	+	+	-	+	+	+	+	-
Modified Godin-Leisure-Time Exercise Questionnaire (MGLTEQ) ⁵³	No	Yes, DAPA	+	+	+	-	+	+	+	+	-
Oxford Physical Activity Questionnaire (OPAQ) ⁵⁴	No	Sent, by authors	+	+	+	+	+	-	+	+	+
Adolescent Physical Activity Recall Questionnaire (APARQ) ⁵⁵	Yes	NA	+	+	+	+	+	+	+	+	+
Past year physical activity in adolescents	Yes	NA	+	+	+	+	-	+	+	+	-

Questionnaire	1.Questionnaire integrated in paper?	2.Did we find the questionnaire in other source? Where?	3.At least 85% of the items are relevant for the construct of interest.	4.At least 85% of the items are relevant for the population of interest.	5.At least 85% of the items are relevant for the context of use of interest.	6.At least 85% of the response options are appropriate for the construct, population, and context of use of interest.	7.The recall period is appropriate for the construct, population, and context of use of interest.	8.The questionnaire is comprehensive for the construct, population and context of use of interest.	9.At least 85% of the items and response options are appropriately worded.	10.At least 85% of the response options match the questions.	Overall Rating
(PYPA A) ⁵⁶											
Computer-based physical activity questionnaire (cPAQ) ⁵⁷	No	No									
Single-item physical activity measure (S-I PA M) ⁵⁸	Yes	NA	+	+	+	+	+	+	+	+	+
Moderate and Vigorous Physical Activity Screening Questionnaire (MPA and VPA S Q) ⁵¹	Yes	NA	+	+	+	+	+	+	+	+	+
PACE+ Adolescent Physical Activity Measure (PACE+ PAM) ⁵¹	Yes	NA	+	+	+	+	+	+	+	+	+
SAYCARE Physical Activity Questionnaire for adolescents (SAYCARE PA Q A) ⁴⁷	No	Yes, sent by authors	+	+	+	+	+	+	+	+	+
The Children's Leisure Activities Study Survey	No	No									

Questionnaire	1.Questionnaire integrated in paper?	2.Did we find the questionnaire in other source? Where?	3.At least 85% of the items are relevant for the construct of interest.	4.At least 85% of the items are relevant for the population of interest.	5.At least 85% of the items are relevant for the context of use of interest.	6.At least 85% of the response options are appropriate for the construct, population, and context of use of interest.	7.The recall period is appropriate for the construct, population, and context of use of interest.	8.The questionnaire is comprehensive for the construct, population and context of use of interest.	9.At least 85% of the items and response options are appropriately worded.	10.At least 85% of the response options match the questions.	Overall Rating
– Proxy and self-reported CLASS- Proxy and self) ²⁵											
Fels PAQ ⁵⁹	Yes	NA	+	+	+	-	+	+	+	+	-
MoMo-Physical-Activity-Questionnaire for Adolescents (MoMo) ⁶⁰	No	No									
Sedentary Behaviour											
South American Youth Cardiovascular and Environmental sedentary behaviour questionnaire for Children (SAYCARE SB Q C) ⁶¹	No	Yes, sent by authors	+	+	+	+	+	+	+	+	+
Eating and Activity Questionnaire Trial - Sedentary behaviour questions ⁶²	No	Yes, sent by authors	+	+	+	-	+	+	+	+	-
HELENA screen time-	No	Yes, sent by	+	+	+	-	+	+	+	+	-

Questionnaire	1.Questionnaire integrated in paper?	2.Did we find the questionnaire in other source? Where?	3.At least 85% of the items are relevant for the construct of interest.	4.At least 85% of the items are relevant for the population of interest.	5.At least 85% of the items are relevant for the context of use of interest.	6.At least 85% of the response options are appropriate for the construct, population, and context of use of interest.	7.The recall period is appropriate for the construct, population, and context of use of interest.	8.The questionnaire is comprehensive for the construct, population and context of use of interest.	9.At least 85% of the items and response options are appropriately worded.	10.At least 85% of the response options match the questions.	Overall Rating
based sedentary behaviour questionnaire (Helena SB Q) ⁶³		authors									
Last-7-day sedentary behaviour questionnaire (SIT-Q-7d) ⁶⁴	Yes	NA	+	+	+	+	+	+	+	+	+
South American Youth Cardiovascular and Environmental sedentary behaviour questionnaire for Adolescents (SAYCARE SB Q A) ⁶¹	No	Yes, sent by authors	+	+	+	+	+	+	+	+	+
Youth Leisure-time Sedentary Behavior Questionnaire (YLSBQ) ⁶⁵	Yes	NA	+	+	+	-	+	+	+	+	-
Sleep											
Children's ChronoType Questionnaire (CCTQ) ⁶⁶	Yes	NA	+	+	+	+	+	+	+	+	+

Questionnaire	1.Questionnaire integrated in paper?	2.Did we find the questionnaire in other source? Where?	3.At least 85% of the items are relevant for the construct of interest.	4.At least 85% of the items are relevant for the population of interest.	5.At least 85% of the items are relevant for the context of use of interest.	6.At least 85% of the response options are appropriate for the construct, population, and context of use of interest.	7.The recall period is appropriate for the construct, population, and context of use of interest.	8.The questionnaire is comprehensive for the construct, population and context of use of interest.	9.At least 85% of the items and response options are appropriately worded.	10.At least 85% of the response options match the questions.	Overall Rating
Physical Activity + Sedentary Behaviour											
GEMS Activity Questionnaire (GAQ) ⁶⁷	No	Yes	+	+	+	-	+	+	+	+	-
ENERGY-child questionnaire (ENERGY-C Q) ⁶⁸	No	No									
International Physical Activity Questionnaire (IPAQ) ⁵²	No	Yes, DAPA	+	+	+	+	+	+	+	+	+
School Health Action, Planning and Evaluation System (SHAPES) physical activity questionnaire ⁶⁹	No	No									
Multimedia activity recall for children and adolescents (MARCA) ⁷⁰	Yes	NA	+	+	+	+	+	+	+	+	+
peas@tees ⁷¹	Yes	NA	+	+	+	+	+	+	+	+	+
Heart Smart Kids (HSK) ⁷²	Yes	NA	+	+	+	+	+	+	+	+	+

Questionnaire	1.Questionnaire integrated in paper?	2.Did we find the questionnaire in other source? Where?	3.At least 85% of the items are relevant for the construct of interest.	4.At least 85% of the items are relevant for the population of interest.	5.At least 85% of the items are relevant for the context of use of interest.	6.At least 85% of the response options are appropriate for the construct, population, and context of use of interest.	7.The recall period is appropriate for the construct, population, and context of use of interest.	8.The questionnaire is comprehensive for the construct, population and context of use of interest.	9.At least 85% of the items and response options are appropriately worded.	10.At least 85% of the response options match the questions.	Overall Rating
Parental Questionnaire for Physical Activity and Sedentary Behaviour (PQPASB) ⁷³	No	Yes, sent by authors	+	+	+	+	+	+	+	+	+
Physical Activity + Sedentary Behaviour + Sleep											
Daughter Questionnaire ⁷⁴	No	No									
Mother and Father Questionnaires ⁷⁴	No	No									

5.2.5. Supplementary Material 5 – Risk of Bias

Table S2. Risk of Bias of Criterion Validity

Questionnaire	Statistical Methods		Overall Rating*
	1. Continuous scores: Correlations, or the area under the receiver operating curve calculated?	2.Dichotomous scores: Sensitivity and specificity determined?	
Physical Activity			
The Children’s Leisure Activities Study Survey - Proxy (CLASS - Proxy) ²⁵	1	1	1
SAYCARE Physical Activity Questionnaire for children (SAYCARE PA Q C) ⁴⁷	1	1	1
Out-of-school physical activity questionnaire (O-O-S PAQ) ⁴⁸	1	NA	1
Habitual Physical Activity Questionnaire (HPAQ) ⁴⁹	1	NA	1
3-Day Physical Activity Recall (3DPAR) ⁵⁰	1	NA	1
Youth Risk Behavior Survey (YRBS) ⁵¹	NA	1	1
Self-Administered Physical Activity Checklist (SAPAC) ⁵⁰	1	NA	1
Health Behaviour in Schoolchildren Physical Activity Questionnaire (HBSC PAQ) ⁵²	1	NA	1
Modified Godin-Leisure-Time Exercise Questionnaire (MGLTEQ) ⁵³	1	NA	1
Oxford Physical Activity Questionnaire (OPAQ) ⁵⁴	1	NA	1
Adolescent Physical Activity Recall Questionnaire (APARQ) ⁵⁵	NA	NA	NA
Past year physical activity in adolescents (PYPAA) ⁵⁶	NA	NA	NA
Computer-based physical activity questionnaire (cPAQ) ⁵⁷	NA	NA	NA
Single-item physical activity measure (S-I PA M) ⁵⁸	1	NA	1
Moderate and Vigorous Physical Activity Screening Questionnaire (MPA and VPA S Q) ⁵¹	1	NA	1
PACE+ Adolescent Physical Activity Measure (PACE+ PAM) ⁵¹	1	NA	1
SAYCARE Physical Activity Questionnaire for adolescents	1	1	1

Questionnaire	Statistical Methods		Overall Rating*
	1. Continuous scores: Correlations, or the area under the receiver operating curve calculated?	2. Dichotomous scores: Sensitivity and specificity determined?	
(SAYCARE PA Q A) ⁴⁷			
The Children's Leisure Activities Study Survey – Proxy and self-reported CLASS- Proxy and self) ²⁵	1	1	1
Fels PAQ ⁵⁹	1	NA	1
MoMo-Physical-Activity-Questionnaire for Adolescents (MoMo) ⁶⁰	1	NA	1
Sedentary Behaviour			
South American Youth Cardiovascular and Environmental sedentary behaviour questionnaire for Children (SAYCARE SB Q C) ⁶¹	1	NA	1
Eating and Activity Questionnaire Trial - Sedentary behaviour questions ⁶²	NA	NA	NA
HELENA screen time-based sedentary behaviour questionnaire (Helena SB Q) ⁶³	4	NA	4
Last-7-day sedentary behaviour questionnaire (SIT-Q-7d) ⁶⁴	1	NA	1
South American Youth Cardiovascular and Environmental sedentary behaviour questionnaire for Adolescents (SAYCARE SB Q A) ⁶¹	1	NA	1
Youth Leisure-time Sedentary Behavior Questionnaire (YLSBQ) ⁶⁵	1	NA	1
Sleep			
Children's ChronoType Questionnaire (CCTQ) ⁶⁶	4	NA	4
Physical Activity + Sedentary Behaviour			
GEMS Activity Questionnaire (GAQ) ⁶⁷	1	NA	1
ENERGY-child questionnaire (ENERGY-C Q) ⁶⁸	NA	NA	NA
International Physical Activity Questionnaire (IPAQ) ⁵²	1	NA	1
School Health Action, Planning and Evaluation System (SHAPES) physical activity questionnaire ⁶⁹	1	NA	1
Multimedia activity recall for children and adolescents (MARCA) ⁷⁰	1	NA	1

Questionnaire	Statistical Methods		Overall Rating*
	1. Continuous scores: Correlations, or the area under the receiver operating curve calculated?	2. Dichotomous scores: Sensitivity and specificity determined?	
peas@tees ⁷¹	1	NA	1
Heart Smart Kids (HSK) ⁷²	NA	NA	NA
Parental Questionnaire for Physical Activity and Sedentary Behaviour (PQPASB) ⁷³	1	NA	1
Physical Activity + Sedentary Behaviour + Sleep			
Daughter Questionnaire ⁷⁴	NA	NA	NA
Mother and Father Questionnaires ⁷⁴	NA	NA	NA

Ratings: 1= Very low Risk of Bias; 2= Low Risk of Bias; 3= Medium Risk of Bias; 4= High Risk of Bias; Abbreviations: NA= Not Applicable.

* According to COSMIN guidelines, overall quality rating is based on 'worst counts method'.

Table S3. Risk of Bias of Reliability and Measurement Error

Questionnaire	Design Requirements (for reliability and measurement error)			Reliability Statistical Methods			Measurement Error Statistical Methods			Overall Rating Reliability/Measurement Error*
	1.Participants stable during measurement period?	2.Time interval appropriate?	3.Similar test conditions in both measurements?	4.Continuous scores: ICC calculated?	5.Dichotomous/nominal/ordinal scores: Kappa calculated?	6.Ordinal scores: weighted kappa calculated?	7. Ordinal scores: Weighting scheme described?	4.Continuous scores: SEM, SDC or LoA calculated?	5.Dichotomous/nominal/ordinal scores: Percentage (positive and negative) agreement calculated?	
Physical Activity										
The Children’s Leisure Activities Study Survey - Proxy (CLASS - Proxy) ²⁵	1	1	1	1	NA	NA	NA	N.R.	NA	1/N.R.
SAYCARE Physical Activity Questionnaire for children (SAYCARE PAQ C) ⁴⁷	1	1	1	3	1	NA	NA	N.R.	N.R.	3/N.R.
Out-of-school physical activity questionnaire (O-O-S PAQ) ⁴⁸	1	1	2	1	NA	NA	NA	N.R.	NA	2/N.R.
Habitual Physical Activity	1	1	2	1	NA	NA	NA	N.R.	N.R.	2/N.R.

Questionnaire	Design Requirements (for reliability and measurement error)			Reliability Statistical Methods			Measurement Error Statistical Methods			Overall Rating Reliability/Measurement Error*
	1.Participants stable during measurement period?	2.Time interval appropriate?	3.Similar test conditions in both measurements?	4.Continuous scores: ICC calculated?	5.Dichotomous/nominal/ordinal scores: Kappa calculated?	6.Ordinal scores: weighted kappa calculated?	7. Ordinal scores: Weighting scheme described?	4.Continuous scores: SEM, SDC or LoA calculated?	5.Dichotomous/nominal/ordinal scores: Percentage (positive and negative) agreement calculated?	
Questionnaire (HPAQ) ⁴⁹										
3-Day Physical Activity Recall (3DPAR) ⁵⁰	1	1	2	3	NA	NA	NA	N.R.	N.R.	3/N.R.
Youth Risk Behavior Survey (YRBS) ⁵¹	1	1	1	1	4	NA	NA	N.R.	N.R.	4/ N.R.
Self-Administered Physical Activity Checklist (SAPAC) ⁵⁰	1	1	2	3	NA	NA	NA	NR	NR	3/N.R.
Health Behaviour in Schoolchildren Physical Activity Questionnaire (HBSC PAQ) ⁵²	3	1	2	1	NA	4	4	N.R.	N.R.	4/N.R.
Modified	1	1	1	3	NA	NA	NA	N.R.	N.R.	3/N.R.

Questionnaire	Design Requirements (for reliability and measurement error)			Reliability Statistical Methods			Measurement Error Statistical Methods			Overall Rating Reliability/Measurement Error*
	1.Participants stable during measurement period?	2.Time interval appropriate?	3.Similar test conditions in both measurements?	4.Continuous scores: ICC calculated?	5.Dichotomous/nominal/ordinal scores: Kappa calculated?	6.Ordinal scores: weighted kappa calculated?	7.Ordinal scores: Weighting scheme described?	4.Continuous scores: SEM, SDC or LoA calculated?	5.Dichotomous/nominal/ordinal scores: Percentage (positive and negative) agreement calculated?	
Godin-Leisure-Time Exercise Questionnaire (MGLTEQ) ⁵³										
Oxford Physical Activity Questionnaire (OPAQ) ⁵⁴	3	1	1	1	NA	NA	NA	N.R.	N.R.	3/N.R.
Adolescent Physical Activity Recall Questionnaire (APARQ) ⁵⁵	1	1	1	1	NA	NA	NA	NR	NR	1/N.R.
Past year physical activity in adolescents (PYPAA) ⁵⁶	2	1	1	3	NA	NA	NA	NR	NR	3/N.R.
Computer-based physical activity questionnaire (cPAQ) ⁵⁷	1	1	1	1	NA	NA	NA	N.R.	NR	1/N.R.
Single-item physical activity	2	1	2	1	NA	NA	NA	N.R.	NA	2/N.R.

Questionnaire	Design Requirements (for reliability and measurement error)			Reliability Statistical Methods			Measurement Error Statistical Methods			Overall Rating Reliability/Measurement Error*
	1.Participants stable during measurement period?	2.Time interval appropriate?	3.Similar test conditions in both measurements?	4.Continuous scores: ICC calculated?	5.Dichotomous/nominal/ordinal scores: Kappa calculated?	6.Ordinal scores: weighted kappa calculated?	7.Ordinal scores: Weighting scheme described?	4.Continuous scores: SEM, SDC or LoA calculated?	5.Dichotomous/nominal/ordinal scores: Percentage (positive and negative) agreement calculated?	
measure (S-I PA M) ⁵⁸										
Moderate and Vigorous Physical Activity Screening Questionnaire (MPA and VPA S Q) ⁵¹	2	1	2	1	NA	NA	NA	N.R.	NA	2/N.R.
PACE+ Adolescent Physical Activity Measure (PACE+ PAM) ⁵¹	2	3	2	1	NA	NA	NA	N.R.	NA	3/N.R.
SAYCARE Physical Activity Questionnaire for adolescents (SAYCARE PA	1	1	1	3	1	NA	NA	N.R.	N.R.	3/N.R.

Questionnaire	Design Requirements (for reliability and measurement error)			Reliability Statistical Methods			Measurement Error Statistical Methods			Overall Rating Reliability/Measurement Error*
	1.Participants stable during measurement period?	2.Time interval appropriate?	3.Similar test conditions in both measurements?	4.Continuous scores: ICC calculated?	5.Dichotomous/nominal/ordinal scores: Kappa calculated?	6.Ordinal scores: weighted kappa calculated?	7.Ordinal scores: Weighting scheme described?	4.Continuous scores: SEM, SDC or LoA calculated?	5.Dichotomous/nominal/ordinal scores: Percentage (positive and negative) agreement calculated?	
Q A) ⁴⁷										
The Children’s Leisure Activities Study Survey – Proxy and self-reported CLASS- Proxy and self) ²⁵	1	1	1	1	NA	NA	NA	N.R.	NA	1/N.R.
Fels PAQ ⁵⁹	1	1	2	1	NA	NA	NA	NR	NA	2/N.R.
MoMo-Physical-Activity-Questionnaire for Adolescents (MoMo) ⁶⁰	1	1	1	1	NA	NA	NA	NR	NA	1/N.R.
Sedentary Behaviour										
South American Youth Cardiovascular and Environmental	1	1	1	3	1	NA	NA	N.R.	NA.	3/N.R.

Questionnaire	Design Requirements (for reliability and measurement error)			Reliability Statistical Methods			Measurement Error Statistical Methods			Overall Rating Reliability/Measurement Error*
	1.Participants stable during measurement period?	2.Time interval appropriate?	3.Similar test conditions in both measurements?	4.Continuous scores: ICC calculated?	5.Dichotomous/nominal/ordinal scores: Kappa calculated?	6.Ordinal scores: weighted kappa calculated?	7.Ordinal scores: Weighting scheme described?	4.Continuous scores: SEM, SDC or LoA calculated?	5.Dichotomous/nominal/ordinal scores: Percentage (positive and negative) agreement calculated?	
sedentary behavior questionnaire for children (SAYCARE SB Q C)										
Eating and Activity Questionnaire										
Trial - Sedentary behaviour questions	1	1	1	3	1	NA	NA	N.R.	N.R.	3/N.R.
HELENA screen time-based sedentary behaviour questionnaire (Helena SB Q)	1	1	1	NA	1	1	1	N.R.	N.R.	1/N.R.
Last-7-day sedentary behaviour questionnaire	1	1	2	1	NA	NA	NA	NR	NA	2/NR

Questionnaire	Design Requirements (for reliability and measurement error)			Reliability Statistical Methods			Measurement Error Statistical Methods			Overall Rating Reliability/Measurement Error*
	1.Participants stable during measurement period?	2.Time interval appropriate?	3.Similar test conditions in both measurements?	4.Continuous scores: ICC calculated?	5.Dichotomous/nominal/ordinal scores: Kappa calculated?	6.Ordinal scores: weighted kappa calculated?	7.Ordinal scores: Weighting scheme described?	4.Continuous scores: SEM, SDC or LoA calculated?	5.Dichotomous/nominal/ordinal scores: Percentage (positive and negative) agreement calculated?	
(SIT-Q-7d)										
South American Youth Cardiovascular and Environmental sedentary behavior questionnaire for adolescents (SAYCARE SB Q A)	1	1	1	3	1	NA	NA	N.R.	NA.	3/N.R.
Youth Leisure-time Sedentary Behavior Questionnaire (YLSBQ)	1	1	1	1	1	1	1	N.R.	N.R.	1/N.R.
Sleep										
Children’s ChronoType Questionnaire (CCTQ)	2	1	2	3	NA	NA	NA	N.R.	NA	3/N.R.

Questionnaire	Design Requirements (for reliability and measurement error)			Reliability Statistical Methods			Measurement Error Statistical Methods			Overall Rating Reliability/Measurement Error*
	1.Participants stable during measurement period?	2.Time interval appropriate?	3.Similar test conditions in both measurements?	4.Continuous scores: ICC calculated?	5.Dichotomous/nominal/ordinal scores: Kappa calculated?	6.Ordinal scores: weighted kappa calculated?	7.Ordinal scores: Weighting scheme described?	4.Continuous scores: SEM, SDC or LoA calculated?	5.Dichotomous/nominal/ordinal scores: Percentage (positive and negative) agreement calculated?	
Physical Activity + Sedentary Behaviour										
GEMS Activity Questionnaire (GAQ)	1	1	1	3	NA	NA	NA	NR	NA	3/N.R.
ENERGY-child questionnaire (ENERGY-CQ)	1	1	1	1	NA	NA	NA	N.R.	NA	1/N.R.
International Physical Activity Questionnaire (IPAQ)	2	1	2	1	NA	4	4	N.R.	N.R.	4/N.R.
School Health Action, Planning and Evaluation System (SHAPES) physical activity questionnaire	1	1	1	NA	NA	1	NA	NA	N.R.	1/N.R.
Multimedia	1	3	1	1	NA	NA	NA	1	NA	3/1

Questionnaire	Design Requirements (for reliability and measurement error)			Reliability Statistical Methods			Measurement Error Statistical Methods			Overall Rating Reliability/Measurement Error*
	1.Participants stable during measurement period?	2.Time interval appropriate?	3.Similar test conditions in both measurements?	4.Continuous scores: ICC calculated?	5.Dichotomous/nominal/ordinal scores: Kappa calculated?	6.Ordinal scores: weighted kappa calculated?	7.Ordinal scores: Weighting scheme described?	4.Continuous scores: SEM, SDC or LoA calculated?	5.Dichotomous/nominal/ordinal scores: Percentage (positive and negative) agreement calculated?	
activity recall for children and adolescents (MARCA)										
peas@tees	1	1	1	1	NA	NA	NA	N.R.	NA	1/N.R.
Heart Smart Kids (HSK)	2	1	3	3	NA	NA	NA	N.R.	NA	3/N.R.
Parental Questionnaire for Physical Activity and Sedentary Behaviour (PQPASB)	2	1	3	1	NA	NA	NA	N.R.	NA	3/N.R.
Physical Activity + Sedentary Behaviour + Sleep										
Daughter Questionnaire	1	1	1	1	NA	NA	NA	N.R.	NA	1/N.R.
Mother and Father Questionnaires	1	1	3	1	NA	NA	NA	N.R.	NA	3/N.R.

Ratings: 1= Very low Risk of Bias; 2= Low Risk of Bias; 3= Medium Risk of Bias; 4= High Risk of Bias. Abbreviations: NA = Not Applicable; N.R.= Not Reported

* According to COSMIN guidelines, overall quality rating is based on “worst counts method”.

Tabela S4. Risk of Bias of Convergent Validity

Questionnaire	Design Requirements		Statistical Methods	Overall Rating*
	Clarity on the comparator instrument(s) measure(s)?	Measurement properties of the comparator instrument(s) are sufficient?	Were design and statistical methods adequate for the hypotheses to be tested?	
Physical Activity				
The Children’s Leisure Activities Study Survey - Proxy (CLASS - Proxy) ²⁵	NA	NA	NA	NA
SAYCARE Physical Activity Questionnaire for children (SAYCARE PA Q C) ⁴⁷	NA	NA	NA	NA
Out-of-school physical activity questionnaire (O-O-S PAQ) ⁴⁸	NA	NA	NA	NA
Habitual Physical Activity Questionnaire (HPAQ) ⁴⁹	1	4	1	4
3-Day Physical Activity Recall (3DPAR) ⁵⁰	NA	NA	NA	NA
Youth Risk Behavior Survey (YRBS) ⁵¹	NA	NA	NA	NA
Self-Administered Physical Activity Checklist (SAPAC) ⁵⁰	NA	NA	NA	NA
Health Behaviour in Schoolchildren Physical Activity Questionnaire (HBSC PAQ) ⁵²	1	4	1	4
Modified Godin-Leisure-Time Exercise Questionnaire (MGLTEQ) ⁵³	NA	NA	NA	NA
Oxford Physical Activity Questionnaire (OPAQ) ⁵⁴	NA	NA	NA	NA
Adolescent Physical Activity Recall Questionnaire (APARQ) ⁵⁵	1	4	1	4
Past year physical activity in adolescents (PYPAA) ⁵⁶	1	4	1	4
Computer-based physical activity questionnaire (cPAQ) ⁵⁷	1	2	1	2
Single-item physical activity measure (S-I PA M) ⁵⁸	NA	NA	NA	NA

Questionnaire	Design Requirements		Statistical Methods	Overall Rating*
	Clarity on the comparator instrument(s) measure(s)?	Measurement properties of the comparator instrument(s) are sufficient?	Were design and statistical methods adequate for the hypotheses to be tested?	
Moderate and Vigorous Physical Activity Screening Questionnaire (MPA and VPA S Q) ⁵¹	NA	NA	NA	NA
PACE+ Adolescent Physical Activity Measure (PACE+ PAM) ⁵¹	NA	NA	NA	NA
SAYCARE Physical Activity Questionnaire for adolescents (SAYCARE PA Q A) ⁴⁷	NA	NA	NA	NA
The Children's Leisure Activities Study Survey – Proxy and self-reported CLASS- Proxy and self) ²⁵	NA	NA	NA	NA
Fels PAQ ⁵⁹	NA	NA	NA	NA
MoMo-Physical-Activity-Questionnaire for Adolescents (MoMo) ⁶⁰	NA	NA	NA	NA
Sedentary Behaviour				
South American Youth Cardiovascular and Environmental sedentary behaviour questionnaire for Children (SAYCARE SB Q C) ⁶¹	NA	NA	NA	NA
Eating and Activity Questionnaire Trial - Sedentary behaviour questions ⁶²	1	4	1	4
HELENA screen time-based sedentary behaviour questionnaire (Helena SB Q) ⁶³	NA	NA	NA	NA
Last-7-day sedentary behaviour questionnaire (SIT-Q-7d) ⁶⁴	NA	NA	NA	NA
South American Youth Cardiovascular and Environmental sedentary behaviour questionnaire for Adolescents (SAYCARE SB Q A) ⁶¹	NA	NA	NA	NA

Questionnaire	Design Requirements		Statistical Methods	Overall Rating*
	Clarity on the comparator instrument(s) measure(s)?	Measurement properties of the comparator instrument(s) are sufficient?	Were design and statistical methods adequate for the hypotheses to be tested?	
Youth Leisure-time Sedentary Behavior Questionnaire (YLSBQ) ⁶⁵	NA	NA	NA	NA
Sleep				
Children's ChronoType Questionnaire (CCTQ) ⁶⁶	NA	NA	NA	NA
Physical Activity + Sedentary Behaviour				
GEMS Activity Questionnaire (GAQ) ⁶⁷	NA	NA	NA	NA
ENERGY-child questionnaire (ENERGY-C Q) ⁶⁸	1	4	1	4
International Physical Activity Questionnaire (IPAQ) ⁵²	1	4	1	4
School Health Action, Planning and Evaluation System (SHAPES) physical activity questionnaire ⁶⁹	NA	NA	NA	NA
Multimedia activity recall for children and adolescents (MARCA) ⁷⁰	NA	NA	NA	NA
peas@tees ⁷¹	NA	NA	NA	NA
Heart Smart Kids (HSK) ⁷²	1	4	1	4
Parental Questionnaire for Physical Activity and Sedentary Behaviour (PQPASB) ⁷³	NA	NA	NA	NA
Physical Activity + Sedentary Behaviour + Sleep				
Daughter Questionnaire ⁷⁴	1	3	1	3
Mother and Father Questionnaires ⁷⁴	1	3	1	3

Ratings: 1= Very low Risk of Bias; 2= Low Risk of Bias; 3= Medium Risk of Bias; 4= High Risk of Bias. Abbreviations: NA = Not Applicable.

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Chapter 6

6.1. Study 3 (Paper III): 24h Movement Questionnaire (QMov24h)
for Adults: Development Process and Measurement Properties

(Submitted to European Journal of Epidemiology)

24h Movement Questionnaire (QMov24h) for Adults: Development Process and Measurement Properties.

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Abstract

Introduction: Sleep, sedentary behaviour, and physical activity are essential components within the 24-hour time frame. Existing questionnaires used to measure these behaviours have insufficient measurement properties and are unsuitable for assessing compliance with the WHO Physical Activity and 24-hour Movement Guidelines.

Purpose: to describe the development process of the 24h Movement Questionnaire (QMov24h) and its testing. The QMov24h was developed to gather detailed information on sleep, sedentary behaviour, and physical activity.

Methods: The sample comprised 117 participants (58% women), aged 30.95 ± 13.56 years. The development process of the QMov24h followed the COSMIN guidelines: (i) Construction of items; (ii) Face validity with end-users; (iii) Content validity with experts; (iv) Criterion validity against accelerometry and convergent validity against diary assessments; and (v) 7-day test-retest reliability.

Results: The QMov24h presented adequate content and face validity. The QMov24h showed moderate criterion validity for sleep ($\rho=0.343; p<0.001$), light physical activity ($\rho=0.31; p=0.002$) and total aerobic physical activity ($\rho=0.343; p<0.001$), as well as strong criterion validity for sedentary behaviour ($\rho=0.428; p<0.001$) and aerobic moderate-to-vigorous physical activity ($\rho=0.534; p<0.001$). Reliability varied from poor to excellent (ICC from 0.38 to 0.962; $p<0.001$) for all questionnaire variables. Regarding compliance of the 24-hour movement guidelines, the questionnaire also showed a strong to almost perfect percentage of agreement with accelerometry (from 69% to 94.3%), and minimal to strong reliability (k from 0.38 to 0.87) between the first and second administrations of the QMov24h.

Conclusions: The QMov24h questionnaire is a valid and reliable tool for assessing levels of MovBeh and compliance with guidelines in adults. Its measurement properties are comparable to, or even better than, those of existing questionnaires, while posing a similar burden to participants. The QMov24h is useful for research, clinical practice, and public health surveillance. The QMov24h has strong psychometric properties, making it suitable for translation, cultural adaptation, and testing in diverse populations for broader international use.

Introduction

Sleep, sedentary behaviour (SB), and physical activity (PA) collectively constitute essential components within the 24-hour time frame. These movement behaviours (MovBeh) are time-dependent since any change in one behaviour is necessarily done at the expense of any of the others¹⁻³. Recently, some countries have begun to develop 24-hour movement guidelines for adults⁴⁻⁶, based on evidence that adequate combinations of MovBeh are health-related^{2,3,7}. Adopting the 24-hour movement guidelines will provide important information for clinicians, researchers, policymakers, and the general population, given the synergistic effects of MovBeh on health. However, this could be challenging for public health surveillance systems, given the difficulty in assessing MovBeh in an integrated fashion.

In large epidemiological studies and clinical settings, self-reported instruments are socially acceptable, cost-effective, avoid burdening participants with cumbersome equipment, and have minimal influence over normal PA patterns⁸⁻¹⁰; therefore, they are often chosen over device-based measurements to assess MovBeh. Certainly, questionnaires offer a more practical and simpler way to collect data from large samples, when compared to device-based instruments. Moreover, questionnaires inherently carry a negligible risk of perturbing regular patterns of MovBeh since the designated reference period for measurement typically precedes their administration¹¹. However, as recently observed in a systematic review, existing questionnaires to measure sleep, SB and PA show insufficient measurement properties and frequent methodological limitations, and none was developed considering the 24-hour MovBeh paradigm¹². Likewise, the existing questionnaires do not align with the 24-hour movement guidelines' paradigm¹³. For example, the International Physical Activity Questionnaire (IPAQ)¹⁴, a widely applied PA questionnaire which was developed to monitor and guide PA policies through comparable data between countries, asks to report only activities lasting more than 10 minutes and does not differentiate muscular strengthening activities from aerobic activities. In contrast, the current PA guidelines of the WHO advocate that "every move counts" and recommends for muscular strengthening activities¹⁵. Moreover,

current questionnaires^{14,16} focus mainly on moderate-to-vigorous PA (MVPA) and there is increasing evidence and interest on the potential health effects of light PA (LPA)^{17,18}, that is typically composed of non-structured and incidental activities¹⁹, which are increasingly represented in the new recommendations. Although it is important to have comparable country data over the years through the stability of self-reported instruments, it is of most importance that available instruments provide accurate information allowing assessment of compliance with current guidelines¹³.

In this context, the new 24-hour MovBeh paradigm and guidelines raise the need to develop new questionnaires to accurately assess MovBeh in an integrated manner and adapt monitoring and surveillance systems to assess compliance with the 24-hour movement guidelines and track changes over time. Therefore, in this context, the objective of this study is to describe the development process of the 24-hour Movement Questionnaire (QMov24h), encompassing stages such as item construction, face validity, content validity, criterion validity, convergent validity, and test-retest reliability. The QMov24h was specifically devised to elicit comprehensive information pertaining to sleep, sedentary behaviour, and physical activity.

Methods

The present study was conducted following the design and analysis of the Consensus-based Standards for the Selection of Health Measurement Instruments (COSMIN) guideline. The process began by developing the *24-hour Movement Questionnaire* (QMov24h) through a three-stage approach: (i) item construction, (ii) face validity testing with end-users, and (iii) content validity testing by experts. Then, measurement properties of the final version of the questionnaire were assessed (criterion and convergent validity; and test-retest reliability).

Prior to data collection, ethics approval was obtained from the Faculty of Sports' Ethics Committee of the University of Porto (CEFADE 17 2022). Written informed consent was provided by all participants. The survey's content and procedures were designed according to the Helsinki Declaration²⁰.

Development of the *24-hour Movement Questionnaire* (QMov24h) for adults

Questionnaire rationale

The QMov24h aims to measure sleep, SB and PA in adults over a 24h period, and to be used as a screening tool in clinical settings, observational studies and clinical trials.

Prior to the development of the QMov24h, and based on the findings and gaps identified in a previous review¹², the following needs were outlined: (i) capture sleep duration, SB duration, PA volume (duration and frequency) and intensity (LPA, Moderate PA [MPA], and Vigorous PA [VPA]) by PA type (aerobic and strength), as well as balance activities; (ii) cover important information from a public health and surveillance points of view, namely to assess compliance with current 24-hour movement guidelines; (iii) be adaptable to future changes in the guidelines, i.e., provide continuous outcome variables; (iv) be informative and educational, so that respondents can understand the concepts covered by the questionnaire before they answer it, to minimize response bias; (v) formulate questions that prevent overlap in the reporting of behaviours, i.e., the sum of all questions should roughly account for 24 hours;

(vi) avoid considerable burden to participants (less than 15 min of answering time); (vii) allow data analysis from each of the MovBeh, whilst respondents answer the whole questionnaire; (viii) be crafted in a neutral format for versatile applicability across various countries and cultural backgrounds, or readily adaptable to diverse international contexts; and (ix) be answered either with paper and pen, or in digital format.

Item construction

A systematic review²¹ was conducted to compile and evaluate the content quality and measurement properties of existing questionnaires measuring MovBeh. This review provided a theoretical and practical background to outline the first QMov24h draft. which was outlined by the authors BR and RS. Throughout three meetings, the authors BR, RS, JE, AM, EVC, ESS, RM and LL, discussed the design, structure and organization of the QMov24h, as well as the definitions and examples included. The order and logic of the questions and item wording were also debated in these meetings.

The first version of the QMov24h comprised 57 items from 13 questions across 6 different domains: sleep (naps and nocturnal sleep); SB (total, during work and out of work); LPA (aerobic and muscular strengthening activities); MPA (aerobic and muscular strengthening activities); VPA (aerobic and muscular strengthening activities); and balance activities.

The recall period of the questionnaire was the usual activity pattern during a typical week, and the chosen response format was hours and minutes per usual day.

Face validity by end-users

Face validity is an informal review of a questionnaire by non-experts to assess its clarity, comprehensibility, and appropriateness for the target group⁸. Additionally, testing face validity can identify misperceptions of the text, which may lead to response errors and provide valuable insights into how respondents understand, retrieve and formulate their responses²². Face validity was tested on the first version of the QMov24h with a convenient group of 25 participants, using a snowball methodology, that strived to maximise participant variation

regarding the PA level, age, gender, literacy, education level and social status. For face validity, cognitive interviews²² were conducted by experienced interviewers following a semi-structured script to understand end-user's opinion on the ease of completion and relevance, comprehensiveness and comprehensibility of the instructions, definitions and examples, items and response options, as well as item wording and recall period⁸. These interviews used a think-aloud methodology and verbal probing^{9,23}, and were recorded and transcribed for analytic purposes. Then data were independently analysed by content analysis by two authors (BR, JE). After content analysis, data were organized in key themes (e.g., difficulties, misunderstandings, suggestions) and discussed with all authors. The insights gained from the interviews were used to draft the second version of the questionnaire by revising the questionnaire's design and rewording some parts of the text.

Content validity by experts

Content validity is a formal assessment by experts to determine the appropriateness of the content and to identify any misunderstandings or omissions⁸. The second version of the questionnaire was reviewed by recognized experts to gather input regarding conceptualization, measurement, analysis, and interpretation of each MovBeh, as well as on the 24-hour movement paradigm.

Fifteen experts from the fields of public health, clinical practice, health promotion and MovBeh epidemiology and psychology were invited to three focus groups. All invited experts agreed to participate. Prior to the focus groups the questionnaire was sent for preliminary consideration. The focus groups were conducted by experienced interviewers²², following the semi-structured script to understand the experts' insights on relevance, comprehensiveness and comprehensibility of the instructions, definitions and examples, items and response options, and item wording and recall period⁸. Experts were also asked to comment on the domains covered and the logic flow of the questionnaire. The focus groups were conducted using a think-aloud methodology and verbal probing^{9,23}, recorded and transcribed for analytic purposes. Afterwards, data were independently analysed by content analysis by two authors (BR, JE) and

discussed with the other authors. The insights gained from the focus groups were used to revise the design of the third version of the questionnaire by rewording parts of the text.

Measurement properties

Participants

Participants were eligible if they were aged between 18 and 64.9 years, resided in Portugal, could read, and write in Portuguese, non-pregnant or breastfeeding and were generally healthy (i.e., without a diagnosed disease or condition that would impact their PA). Participants were chosen by a convenience, non-random strategic sampling procedure (i.e., snowball), and 130 participants were invited by direct contact through existing networks. Recruitment took place between May and July of 2023. In addition to the questionnaire, we also collected some demographic information (e.g., age, gender, socio-economic status) and height and weight were collected. Body mass index (BMI) was computed as weight in kilograms divided by height in meters squared.

Criterion and convergent validity

A triaxial accelerometer (Actigraph GT3X, Actigraph, Pensacola, Florida, USA), was used to establish the criterion validity of the QMov24h, capturing minute-by-minute observations of whole-body motion. The Actigraph accelerometers have often been used as a concurrent measure to validate MovBeh questionnaires^{12,24}. The Actilife version 6.13.4 software (Actigraph, Pensacola, FL, USA) was used to download and analyse accelerometer data.

Participants were asked to wear the accelerometer on their right hip during 24-hour for 7 days, except for water-based activities. Seven days of accelerometry monitoring has been shown to capture more than 80% of the interindividual variation in adult physical inactivity and activity²⁵. To inclusion criterion was applied whereby participants were only included if they had worn the accelerometer for a minimum of 4 days, including one weekend day (≥ 16 hours per day was considered a valid day). All participants received verbal and written instructions for the proper use of the accelerometer and were instructed

to keep the monitor snugly against the body so that it was not allowed to flop around.

Data were collected with a sampling rate of 100 Hz and reintegrated for analysis purposes into 60 seconds epochs. The accelerometer count data were summarized in terms of hours/minutes per day and week. The cut points used to classify accelerometer data, as sedentary time was defined as 0–99 counts per minute (cpm), for LPA as 100–2019 cpm, MPA as 2020–5998 cpm, and for VPA as >5998 cpm²⁶. Sleep was manually and visually screened, considering the diary and accelerometer files. For 24-hour movement guidelines compliance, we used the adults' Canadian guidelines as an example, as follows: Seven to nine hours of good-quality sleep, limiting SB to 8 hours or less, at least 150 minutes per week of aerobic MVPA and at least two days of muscle-strengthening activities per week. Participants were categorised as having MovBeh levels above or below the Canadian guidelines' thresholds. Non-wear time was identified as a continuous period of > 60 min with no activity or with information from the logbook. Data were processed according to standard quality assurance procedures²⁶.

To support and complete accelerometry data analysis, a MovBeh log was also provided to the participants, so that they could record their activity during the seven days, regarding the hours the participant fell asleep and woke up, time and intensity of strength training, moments when the accelerometer was taken out and reason. Potential irregularities, e.g., problems with the monitor or non-wear time, were also documented. This log also served to evaluate convergent validity (i.e., the extent of the agreement with another [non-criterion] measure that should assess the same behaviour parameter based on face and content validity) for the outcomes that were not possible to validate against accelerometry (i.e., time and intensity of strength training and time on balance activities).

Criterion and convergent validity were further assessed by comparing responses from the questionnaire with data from the accelerometers and movement behaviour log. The evaluated outcomes against the accelerometer were: the time spent on a usual weekday (i.e., workday), on a usual weekend day (i.e., non-workday) and the mean of the weekday and weekend day, for nocturnal sleep, naps, SB and LPA, time and frequency of moderate and

vigorous intensities for aerobic PA; time and frequency of aerobic MVPA PA (by summing MPA and VPA variables); time spent in total PA (by summing all PA intensity variable). Time spent in strength and balance activities, was evaluated against the log.

Reliability

Test–retest reliability was evaluated by asking participants to complete the questionnaire seven days after first taking it. This period was thought to be long enough to ensure that participants could not recall the first moment of the questionnaire filling from memory, and short enough to prevent large changes in MovBeh levels⁸. The evaluated scores were the same as for criterion and convergent validity, plus the MovBeh patterns.

Data analysis

The distribution of the MovBeh data was examined before analysis. Since some data distributions were nonnormal, nonparametric tests were used. Spearman rank correlations were used to assess questionnaire validity scores, comparing the accelerometer and QMov24h data (criterion validity) and the accelerometer and accelerometer log results (convergent validity).

For interpretation of Spearman's rho values, standard convention was used: negligible (0.01-0.19); weak (0.20-0.29); moderate (0.30-0.39); strong (0.40-0.69) and very strong (≥ 0.70)²⁷. Based on results from similar studies Spearman's $\rho \geq 0.30$ was considered adequate^{28,29}. Bland-Altman plots assessed agreement between QMov24h and accelerometer data³⁰. In the Bland-Altman plot, proportional bias was verified via regression analysis.

Percentage of agreement was used to assess adherence to the Canadian 24-hour Movement Guidelines. For percentage of agreement, 0-4% represented no agreement, 4-15% represented minimal agreement, 15-35% represented a weak agreement, 35-63% represented a moderate agreement, 64-81% represented a strong agreement, and 82-100% represented an almost perfect agreement^{31,32}.

Two-way mixed effects, single measure, absolute agreement Intraclass Correlation Coefficients (ICCs) ³³ with a 95% confidence interval (CI) were calculated to assess test-retest reliability scores from the two administrations of the QMov24h. All assumptions for correlation were examined prior to analyses. ICCs coefficient values of <0.50 indicated poor reliability, 0.50 - 0.75 represented moderate reliability, 0.75-0.90 good reliability, and > 0.90 excellent reliability³³. To check compliance with guidelines regarding reliability, Cohen's Kappa and percentage of agreement were computed. For Cohen's Kappa, 0-0.20 represented no reliability, 0.21-0.39 minimal reliability, 0.40-0.59 weak reliability, 0.60- 0.79 moderate reliability, 0.80-0.90 strong reliability, and > 0.90 almost perfect reliability³¹. For percentage of agreement, the classification mentioned above was used.

Bland-Altman plots were also used to assess agreement between the two administrations of the QMov24h.

All analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 28. Statistical significance was set at $p < 0.05$.

Results

Development of the questionnaire

Face validity by end-users

Twenty-five cognitive interviews were conducted (60% female; $46 \pm 18,9$ years old; 46.2% with full-time job and 26.9% were undergraduate). The interviews began with participants answering the questionnaire individually and in silence; then participants expressed their views, opinions, and doubts following the interview script. Participants took 13.62 ± 2.82 min to answer the questionnaire.

From the interviews, it became clear that the respondents understood the questionnaire as a whole, agreed with the general structure (divided into sections, by MovBeh) and with the questionnaire layout. All participants understood all the concepts and definitions presented in the questionnaire. However, most participants found it difficult to apply the concept of “usual time” to the questions, particularly those whose routines varied from week to week.

Regarding the introduction section of the QMov24h, all participants considered the introduction clear and understood the recall period; however, some participants did not understand that MovBeh were mutually exclusive. There were some minor suggestions regarding the wording of this questionnaire section (e.g., to explicitly state that one can only do one MovBeh at a time; to improve the visual highlighting of the examples provided in the instructions).

Sleep and SB related questions were considered the easiest to answer, compared to PA questions. All participants considered the questions and response format about sleep and SB relevant, comprehensive, and comprehensible. Specifically, in the sleep questions, all participants understood they were not to consider the time they spent lying down without sleeping. The instructions were also found to be adequate. Six participants considered that the example in the SB section, regarding sitting during meals, should be placed at the beginning of the examples because this time of day was harder to consider.

PA questions were the hardest to recall for all participants, mainly for less active ones. Nevertheless, participants considered the questions and response format relevant, comprehensive, and understandable. In this section of the

questionnaire, eight participants suggested changing the layout structure of the questions for MVPA. The instructions of this section of the questionnaire were considered adequate by all participants. However, all participants stated that the information regarding physical activity intensities was too descriptive. They suggested simplifying the text and adding images. This suggestion was taken on board and, during the draft of the second version of the questionnaire, an infographic was developed to explain the concepts and examples of PA.

Overall, the cognitive interviews led to some adjustments in the questionnaire, namely in the layout structure and rewording of some items and instructions. Given that 11 participants left some sections of the questionnaire in blank, because they didn't do some behaviours (e.g. naps), the instructions of the questionnaire were adjusted to ask participants to answer zero ("0") whenever they did not perform a given behaviour. No additional items were included in the questionnaire, because all the participants believed that the questionnaire adequately covered their MovBeh.

The research team concluded that the changes made to the first version of the questionnaire did not justify new cognitive interviews with end-users, and consequently decided to finish the face validity process.

Content validity

During the interviews, all experts agreed that the questionnaire adequately covered the MovBeh that can be done over 24-hour periods. The experts' interviews mainly considered different elements of the questionnaire (instructions, descriptions of PA intensities, and examples for each MovBeh). The introduction section of the questionnaire was validated by all experts, with minor suggestions for rephrasing some sentences. The order of the items was considered to have logic flow. The experts agreed to change the tables format to save space (i.e., instead of the questions about weekend days being placed below weekdays, the two were placed side by side). Also, the format of the response changed to save space (i.e., changed from ____:____ (hours:minutes) to ____h____min). Overall, the definitions, response format, instructions and recall period were considered adequate.

All experts considered the relevance, comprehensiveness and comprehensibility of the sleep and naps questions adequate.

The relevance, comprehensiveness, and comprehensibility of the total SB questions were also considered adequate. However, the experts considered that from a public health surveillance point of view, it would be more relevant that participants reported their SB during leisure and work time, rather than the screen time and passive transport as outlined in the questionnaire's first draft. This suggestion was accepted.

All the experts valued the PA infographic explain PA types and intensities, considering it as potentially important to reduce reporting bias. The experts considered PA questions to be relevant, comprehensive, and comprehensible. The layout and structure of the questions were considered innovative and a differentiating factor from existing questionnaires. Additionally, the experts recommended including the same pictograms of the infographic as visual aids for defining concepts throughout the questionnaire.

Overall, the feedback received from the experts was very positive, with few substantial changes being suggested. Refinements based on the suggestions provided by experts were made, and the research team considered that there was no need to repeat the face validity phase with the end-users.

Description of the questionnaire's final version

The QMov24h (See Annex 1) is a self-administered recall instrument comprising 56 items from 17 questions across 6 main domains. The questionnaire instructs participants starting from sleep behaviours (naps and nocturnal sleep) through SB (total, leisure, and work) to LPA (aerobic and muscle-strengthening activities), MPA (aerobic and muscle-strengthening activities) and VPA (aerobic and muscle-strengthening activities) and balance activities.

In terms of recall and assessment period and response formats for sleep, SB, and LPA domains, the questionnaire asks for how much time, on average, the respondent spends in each behaviour, in a usual weekday (workday) and weekend day (non-workday) (e.g., *In a typical week, on average, how much time do you spend sitting, reclining, or lying down, per day?*). For MPA, VPA and balance activities, the questions and response format considered each

weekday and weekend day (e.g., *Estimate the average time, for each day of the week, that you do moderate-intensity aerobic activity.*). This difference between behaviours was made because sleep, SB and LPA are performed daily. At the same time, MPA and VPA and balance activities tend to be more structured activities that follow weekly patterns.

The outcomes of the QMov24h are the time (hours or minutes) spent per day in sleep and LPA; and the frequency (i.e. number of days); and the time (hours or minutes) spent in MPA (aerobic and strength activities), VPA (aerobic and strength activities) and balance activities, with these being able to be averaged by day. Given the continuous nature of the questionnaire outcomes, all outcomes can be categorized to assess compliance with 24-hour movement guidelines. The questionnaire was structured into three distinct sections: sleep, SB, and PA. These sections can be analysed independently or jointly.

Recognizing the complexity of responding to questionnaires measuring complex behaviours, it was acknowledged that incorporating relevant cues and examples of the behaviours of interest was crucial for designing effective assessment tools³⁴. For instance, to facilitate participants' understanding of the applicable activities for each question, the questionnaire provided a definition and multiple examples for each behaviour and intensity.

Measurement properties

Socio-demographic characteristics

A total of 130 adults were invited for the criterion and convergent validity and reliability studies, of these, 100 participants completed at least the first questionnaire and provided sufficient valid days of accelerometry (criterion validity study), and 117 completed the questionnaire on both occasions (convergent validity and reliability studies). Participants of the face-validity study did not participate in the criterion and convergent validity and reliability studies. For the criterion validity study (n=100; 61% women) participants were 31.33 ± 13.68 years old, 33% worked full-time, and 44% were university students. For the convergent validity and reliability studies (n=117; 58.1% women) participants were 30.95 ± 13.56 years old, 34% worked full-time, and 54% were university students (Table 1). Participants took between 10 to 15 min to respond

the questionnaire. On average the answer to all questions summed 23 hours and 13.2 min.

---INSERT TABLE 1 HERE---

Validity results

Criterion-validity

As presented in Table 2, all main variables showed adequate criterion validity (i.e., $\rho \geq 0.30$; $p < 0.05$). Regarding nocturnal sleep variables, Spearman correlations showed weak to strong associations between the accelerometer and sleep variables as measured by the questionnaire (ρ from 0.27 to 0.41; $p < 0.05$). Figure 1a. illustrates the Bland Altman plot for total sleep showing good agreement between the accelerometer and QMov24h, without proportional bias ($p = 0.52$), with a mean difference of 0.02 ± 0.88 h/day and a Limits of Agreement (LoA) between -1.72 and 1.75 h/day. For SB variables, Spearman correlations showed moderate to strong associations between the accelerometer and all the SB variables (ρ from 0.36 to 0.43; $p < 0.001$). Figure 1b. illustrates the Bland-Altman plot for total SB, showing good agreement between the accelerometer and QMov24h, with a slight underestimation of SB from the questionnaire ($p \leq 0.001$), with a mean difference of -1.01 ± 1.92 h/day and a LoA between -4.77 and 2.74 h/day. For LPA variables, Spearman correlations showed weak to moderate associations between the accelerometer and LPA variables as measured by questionnaire (ρ from 0.25 and 0.33; $p < 0.001$). Figure 1c. illustrates the Bland-Altman plot for total LPA, showing good agreement between the accelerometer and QMov24h, with a slight underestimation of LPA from the questionnaire ($p \leq 0.001$), with a mean difference of -0.20 ± 2.43 h/day and a LoA between -4.96 and 4.56 h/day). For aerobic MPA, VPA, MVPA, and total PA variables (min/day), Spearman correlations showed moderate to strong associations between the accelerometer and all these PA variables (ρ from 0.37 to 0.57; $p < 0.001$). Figure 1d. illustrates the Bland-Altman plot for aerobic MVPA, showing a good

agreement between the accelerometer and QMov24h, with an overestimation of aerobic MVPA from the questionnaire ($p \leq 0.001$), with a mean difference of 15.11 ± 88.26 min/day and a LoA between -157.88 and 188.10 min/day).

---INSERT TABLE 2 and FIGURE 1 HERE---

Regarding compliance with the 24-hour movement guidelines, when variables were categorized as below or above the guidelines' thresholds (e.g. 150 min/week of MVPA), the percentages of agreement between the questionnaire responses and the accelerometer results showed a strong to almost perfect agreement (69% to 94.3%).

---INSERT TABLE 5---

Convergent validity

Convergent validity analyses are presented in Table 3. All main variables showed adequate convergent validity (i.e., $\rho \geq 0.30$; $p < 0.05$), when compared against the MovBeh diaries. For naps variables, Spearman correlations showed weak to moderate associations between the MovBeh diary and naps variables assessed by questionnaire (ρ from 0.23 to 0.37; $p < 0.05$). For strength MPA, VPA, MVPA variables (both hours/week and times/week), Spearman correlations showed very strong associations between the MovBeh diary, and all these PA variables as assessed by questionnaire (ρ from 0.85 to 0.97; $p < 0.001$). Figure 1e. illustrates the Bland-Altman plot for strength MVPA, showing a good agreement between the diary and QMov24h, without proportional bias from the questionnaire ($p = 0.93$), with a mean difference of 5.51 ± 196.17 min/day and a LoA between -390.00 and 379.00 min/day. For balance activities variables (hours/week and times/week), Spearman correlations showed very strong associations between the diary and all balance variables (ρ from 0.73 to 0.80; $p < 0.001$).

---INSERT TABLE 3---

Reliability

Table 4 presents the results of test-retest analyses comparing the first administration of the QMov24h with the second.

For nocturnal sleep variables, ICCs showed good agreement between the first and second administration of the questionnaire (ICC from 0.78 to 0.79; $p < 0.001$). Figure 2a. illustrates the Bland-Altman plot for total sleep, showing good reliability without proportional bias ($p = 0.56$) between the two administrations of the questionnaire, with a mean difference of 0.03 ± 0.49 h/day and a LoA between -0.93 and 0.98 h/day. For naps variables, ICCs showed significant and moderate to good agreements between the first and second administrations (ICC of 0.64 to 0.75; $p < 0.001$). For SB variables, ICCs showed good to excellent agreements between the first and second administration of the questionnaire (ICC from 0.75 to 0.93; $p < 0.001$). Figure 2b. illustrates the Bland-Altman plot for total SB, showing good reliability without proportional bias ($p = 0.33$) between the two administrations of the questionnaire, with a mean difference of 0.36 ± 1.42 h/day; LoA between -2.43 and 3.14 h/day. For LPA variables, ICCs showed good agreement between the first and second administration of the questionnaire (ICC from 0.83 to 0.84; $p < 0.001$). Figure 2c. illustrates the Bland-Altman plot for total LPA, which showed good reliability without proportional bias ($p = 0.82$) between the two administrations of the questionnaire, with a mean difference of 0.11 ± 1.44 h/day; LoA between -2.71 and 2.93 h/day. For aerobic MPA, VPA, MVPA, total PA, ICCs showed moderate to good agreements between the first and second administration of the questionnaire (ICC from 0.72 to 0.83; $p < 0.001$). Figure 2d illustrates the Bland-Altman plot for aerobic MVPA, indicating good reliability with a slight overestimation ($p \leq 0.001$) of the first administration, with a mean difference of 5.01 ± 48.54 min/day; LoA between -90.07 and 100.21 min/day. For strength MPA, VPA, MVPA variables (hours/week and times/week), ICCs showed significant and moderate to good agreements between the first and second administration of the questionnaire (ICC from 0.73 to 0.89; $p < 0.001$). Figure 2e illustrates the Bland-Altman plot for strength MVPA, indicating good reliability without proportional bias ($p = 0.78$) between the two administrations of the questionnaire, with a mean difference of 19.78 ± 190.80 min/day; LoA between -393.75 and -354.19 min/day). For aerobic and strength MVPA and total PA, ICCs showed good agreement between the first and second administration of

the questionnaire (ICC of 0.80 and 0.82, respectively; $p < 0.001$). For balance activities variables (hours/week and times/week), ICCs showed poor to moderate agreement between the first and second administration of the questionnaire (ICC of 0.38 and 0.73, respectively; $p < 0.001$).

Regarding compliance with the 24-hour movement guidelines, when variables were categorized as below or above the guidelines' thresholds (e.g. 150 min/week of MVPA), the percentages of agreement between the two administrations of the questionnaire results showed minimal to strong reliability (k from 0.38 to 0.87; $p < 0.001$), while the percentages of agreement represented a strong to almost perfect agreement (80.3% to 94.0%).

Discussion

The *24-hour Movement Questionnaire* (QMov24h) was developed to assess population MovBeh levels and compliance with the 24-hour movement guidelines. On average the answer to all questions of the QMov24h summed 23 hours and 13.2 min. The QMov24h presented adequate content and face validity. The QMov24h showed moderate criterion validity for sleep, LPA and total aerobic PA, and strong criterion validity for SB and aerobic MVPA. The questionnaire also displayed good agreement with accelerometer measures in all main MovBeh variables, with SB and LPA being slightly underestimated in the questionnaire, as well as with aerobic MVPA being marginally overestimated by the questionnaire. The QMov24h presented moderate convergent validity for naps and very strong convergent validity for all strength and balance variables. Reliability of the QMov24h varied from good to excellent in all questionnaire variables; between the first and second administration of the questionnaire, there was good agreement for all questionnaire variables, with aerobic MVPA being slightly overestimated on the first administration of the questionnaire. Regarding compliance with the 24-hour movement guidelines, the questionnaire revealed strong to almost perfect percentage of agreement (criterion validity) with accelerometry and minimal to strong reliability between the first and second administrations of the questionnaire.

The QMov24h showed adequate face and content validity following minor adjustments to wording and layout structure, which were based on feedback from end-users and experts during the questionnaire's development process. These forms of validity are crucial for questionnaire development, but are often neglected²². In fact, only a few studies have assessed the relevance, comprehensiveness, and comprehensibility of questionnaires⁸.

Validity and reliability of sleep variables

The questionnaire presented adequate validity and reliability for sleep variables, consistent with the validation results of other sleep questionnaires. However, caution should be exercised when making direct comparisons, as other validations of sleep questionnaires have typically focused on the validity of summary scores based on multiple dimensions of sleep, including sleep quality, rather than specifically on sleep duration or against different criterion

methods^{35,36}. For example, the validation study of the Daily Activity Behaviours Questionnaire (DABQ)³⁷, showed greater criterion validity than our QMov24h; however, it was conducted with ActivPaL inclinometers placed on the thigh. Nevertheless, the QMov24h showed better reliability than the DABQ. Other sleep questionnaires tend to overestimate sleep duration when compared with accelerometry^{36,38}, and the QMov24h showed a good agreement without proportional bias between the two methods.

The DABQ³⁷ did not validate the questions regarding naps, which is consistent with a recent systematic review that reported the lack of studies validating questions for naps¹². We addressed this gap, and the QMov24h showed adequate convergent validity for this sleep variable.

Validity and reliability of sedentary behaviour variables

All SB variables showed adequate criterion validity and good to excellent reliability. Despite having different methodologies (e.g., accelerometer model, body placement, cut points, etc.), the total SB variable from the QMov24h ($\rho=0.43$) achieved slightly better validity results when compared with most of the SB questionnaires ($r=0.32$)³⁹. Additionally, the QMov24h had better SB validity results than well-established questionnaires, such as the usual week IPAQ long (ρ from 0.14 to 0.22) and short (ρ from 0.07 to 0.26, against accelerometers) forms²⁹, and the GPAQ ($\rho=-0.20$, against pedometers)¹⁶. QMov24h showed a good agreement with a slight underestimation of the questionnaire (-1.01 ± 1.92 h/day), which is similar to some studies^{37,40}, but better than others⁴¹⁻⁴³.

In terms of reliability, the QMov24h's total SB variable ($ICC=0.80$) outperformed most SB questionnaires ($ICC=0.66$)³⁹. Furthermore, the QMov24h demonstrated similar reliability to the long ($\rho = 0.74$ to 0.93) and short ($\rho = 0.58$ to 0.94) forms of the usual week IPAQ²⁹. QMov24h exhibited good agreement in test-retest reliability, without proportional bias between the two questionnaire administrations. In contrast, some studies reported a slight overestimation in the results of the initial questionnaire administration⁴⁴.

Regarding the reliability of SB at work ($ICC=0.93$) and during leisure time ($ICC=0.81$), the QMov24h yielded better results than the Sedentary, Transportation and Activity Questionnaire (STAQ)⁴³ and the SIT-Q⁴⁴, two

questionnaires devoted to the duration of SB, with ICCs of 0.71 and 0.67, and ICC of 0.81 and 0.61, respectively. It is worth highlighting that testing the criterion validity of behavioural domains is a complex challenge, although it has been done with cameras⁴⁵.

Validity and reliability of PA variables

Possibly because LPA has only recently been included in the WHO guidelines¹⁵, and given that evidence on the health-related benefits of LPA is quite recent^{46,47}, there are few questionnaires assessing it^{12,48,49}. For example, the widely used IPAQ¹⁴ and GPAQ¹⁶ do not assess LPA. The Community Health Activities Model Program for Seniors questionnaire has been modified to measure LPA; however, with low validity ($r=0.06$) and only in older adults⁵⁰. The Sedentary Behaviour and Light-intensity Physical Activity Questionnaire was recently developed to measure LPA and SB, and has shown adequate validity ($\rho=0.43$) and reliability ($ICC=0.70$)⁵¹. However, it has limitations as it does not measure all PA intensities or sleep, which is important for measuring the 24-hour movement behaviour composition. Additionally, it was developed with a clinical population, so its measurement properties in the general population are unknown. The DABQ³⁷ showed an adequate validity ($\rho=0.45$) for LPA; although, unlike QMov24h, this questionnaire does not include specific questions for LPA, rather, LPA is *a posteriori* calculated as the remaining time to the total time spent in MVPA. On the other side, QMov24h displayed greater reliability than the DABQ for total LPA ($ICC=0.69$ vs. $ICC=0.84$). Additionally, QMov24h showed a higher agreement for LPA (mean difference=0.20 h/day, i.e., 12 min/day) with accelerometry in the Bland Altman analysis than DABQ (mean difference=134.5 min/day). As such, QMov24h is one of the first valid and reliable questionnaires focused on assessing all MovBeh, including LPA.

The QMov24h study found significant moderate to strong significant associations between accelerometry and aerobic MPA, VPA and MVPA, and total aerobic PA variables (in min/day) with Spearman correlation coefficients ranging from 0.37 to 0.57 ($p<0.001$). These results are comparable to or even better than those reported in other validation studies, such as the IPAQ and GPAQ, which reported Spearman correlation coefficients between 0.27 and 0.49^{28,29,52-54}. For example, a study validating the GPAQ for the European

context showed negligible validity for aerobic MPA ($\rho=0.16$)⁵⁵, whereas the QMov24h exhibited strong validity ($\rho=0.50$). Also, with a Spearman correlation of 0.53 for aerobic MVPA, the QMov24h seems to have a better criterion validity for this intensity than almost all of the questionnaires included in a recent systematic review on the measurement properties of MovBeh questionnaires¹². Additionally, in the present study, Bland Altman analysis presented a good agreement between the accelerometer and QMov24h, albeit with an overestimation of aerobic MVPA from the questionnaire of 15.11 ± 88.26 min/day. In comparison, others overestimated MVPA by 46 min/day (GPAQ) and 76 min/day (IPAQ) against accelerometry⁵⁶. Regarding test-retest reliability, the QMov24h showed moderate to good agreement (ICC of 0.72 to 0.83; $p < 0.001$). These results align with those from GPAQ and are higher to the IPAQ⁴⁸. Compared with DABQ³⁷, a questionnaire that also considers the 24h MovBeh paradigm, QMov24h displayed better criterion validity (ρ : 0.38 vs 0.53) and reliability (ICC: 0.65 vs. 0.82) for aerobic MVPA variables.

The strength MPA, VPA, and MVPA variables (hours/week and times/week) showed very strong associations with the diary (ρ from 0.85 to 0.97; $p < 0.001$). Having a questionnaire that includes items related to muscle strengthening activities is of utmost importance because, although muscle strengthening activities have been included in the guidelines since 1995⁵⁷, it is not a PA type that is usually measured in clinical and surveillance studies. Potentially because until now, there were no properly validated questionnaires that included questions/items on muscle strengthening activities¹². Although the current WHO PA guidelines¹⁵, and the Canadian 24-hour Movement guidelines⁴ only mention the frequency of muscle-strengthening activities (twice a week), our questionnaire goes beyond that and also records the time spent on these activities. In this regard it would be ideal to have a questionnaire that included other domains of strength, such as intensity, sets and repetitions. However, this would make the questionnaire longer and more complex. Additionally, research has shown that engaging in muscle-strengthening activities is beneficial, regardless of the specific characteristics of the activities⁵⁸. Indeed, assessing, monitoring, and exploring health-related associations of the frequency and duration of muscle-strengthening activities, with valid and reliable questions at a population level, will be paramount for future updates of the guidelines. The

same applies to the questions on balance activities. Although balance activities are only mentioned in the older adults' guidelines¹⁵, these are still important health-related activities across the lifespan. Besides that, the recently created 24-hour movement guidelines for Finland (UKK Institute, 2022), already include balance activities for adults. Additionally, the justification for including this PA type in the QMov24h is due to ongoing validation studies for older adults. The aim is to have a single questionnaire that can assess 24-hour MovBeh in a standardized way throughout adulthood (18 years and older).

Compliance with guidelines

The QMov24h showed adequate validity (69% to 94.3% of agreement) and reliability (k of 0.38 to 0.87; 80.3% to 94.0% of agreement) results for classifying compliance with the Canadian 24-hour Movement Guidelines. The strategy of having continuous response formats and then categorizing the answers *a posteriori*, is stronger than presenting categorical response options. Indeed, fixed categorical response options (i) do not allow capturing the whole *spectrum* of possible responses, (ii) limit analysing dose-response effects and (iii) compromise further analysis and categorizations. In addition, the use of pre-defined categories as response options may influence how respondents perceive and answer the questions^{59,60}. The QMov24h is adaptable to changes in guidelines, unlike questionnaires with categorical response formats. Of note, a validation study comparing two versions of the questionnaire (one with categorical response format and the other with continuous answering mode) found better results for the continuous answering mode version⁶¹.

Strengths and limitations

The study's rigorous methodological approach in developing the QMov24h is a significant strength. The study followed the guidelines of the Consensus-based Standards for the Selection of Health Measurement Instruments (COSMIN) for design and analysis of the QMov24h. This involved a three-stage approach: (i) item construction; (ii) testing face validity with end-users; and (iii) content validity with MovBeh experts. This approach was essential to minimize participant reporting errors by ensuring that questions and instructions were adequately worded for the target population. Another strength

of this study is the combination of accelerometry with a contextualized diary for validity and reliability studies.

The questionnaire's major strengths lie in its development as a response to the shortcomings of existing questionnaires. For instance, it underwent face and content validity assessments, and included questions on the three MovBeh using a 24-hour continuum logic. Additionally, the questionnaire measures LPA, muscle strengthening, and balance activities, which aligns with current guidelines. The QMov24h was designed to be informative, self-explanatory, and visually appealing to minimize recall errors and avoid response bias. Furthermore, the QMov24h demonstrated adequate validity and reliability for each MovBeh and their combination.

This study is not without its limitations. Firstly, the use of a sample with a high proportion of university students (although with a range of participants in terms of age, gender and education); secondly, the use of only one hip-worn accelerometer rather than a combination of accelerometers (hip for PA, thigh for SB and wrist for sleep), recognizing that such a study design would significantly increase the burden on participants. Furthermore, although the hip-worn accelerometer has been shown to be the best option for PA behaviours (mainly MVPA), the thigh-worn accelerometers (e.g. ActivPal) have been shown to be better for posture behaviours (e.g. SB)⁶⁵. For example, evidence suggests that actigraphy promotes overestimation of SB in comparison to ActiPAL on the thigh⁶⁶.

Conclusions

The QMov24h questionnaire is a valid and reliable tool for assessing levels of MovBeh and compliance with guidelines in adults. Its measurement properties are comparable to, or even better than, those of existing questionnaires, while posing a similar burden to participants. The QMov24h is useful for research, clinical practice, and public health surveillance. The QMov24h has strong psychometric properties, making it suitable for translation, cultural adaptation, and testing in diverse populations for broader international use.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethic Committee of the Faculty of Sport at the University of Porto (CEFADE 17 2022). Participants signed an informed written consent prior to the commencement of the study.

Availability of data and other materials

The data are available upon reasonable request from the authors.

Competing interests

The authors declare that they have no competing interests.

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Author's contributions

B.R. and R.S. conceived the study. B.R., P.J., A.M., J.E., E.V.C., E.C., L.L., E.S-S., A.V-S, D.C., R.M. and R.S. were involved in all the phases of the development of the questionnaire. B.R., L.L., J.E., R.S., A.V-S and E.S-S collected data. B.R., P.J. and R.S. analysed the data. B.R. wrote the first draft of the paper. The other members of the QMov24h working group were involved

in the content validity phase of the questionnaire as experts. All authors discussed the results, provided intellectual input, and contributed to the writing of the final version of the manuscript.

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Tables and figures

Table 5. Participants' characteristics

	Validity (n=100)	Reliability (n=117)
Gender		
Men	39 (39.0%)	49 (41.9%)
Women	61 (61.0%)	68 (58.1%)
Age (years)	31.3 ± 13.7	31.0 ± 13.6
Education		
Less than high school	8 (8%)	8 (6.8%)
High school/Vocational education	27 (27%)	36 (30.8)
University degree incomplete	19 (19%)	20 (17.1)
Undergraduate	30 (30%)	33 (28.2%)
Master's degree	14 (14%)	17 (14.5)
PhD	2 (2%)	3 (2.6%)
Employment		
Full-time	34 (34%)	39 (33.3%)
Part-time	4 (4%)	4 (3.4%)
Unemployed	2 (2%)	2 (1.7%)
Student	44 (44%)	53 (54.3%)
Retired	5 (5%)	5 (4.3%)
Domestic work	10 (10%)	13 (11.1%)
Inability to work	1 (1%)	1 (0.9%)
Body mass index (kg/m²)	23.52 ± 3.67	23.38 ± 3.53

Data are n(%) or mean±SD

Table 6. Validity of movement behaviours variables from the QMov24h against accelerometer (n=100)

Movement Behaviour variable	Questionnaire variable description	Questionnaire data	Accelerometer data	rho	p
		Mean minutes/hours (95% CI)	Mean minutes/hours (95% CI)		
Nocturnal sleep					
Weekday/workday (h/day)	Hours of sleep at night on a weekday/workday	7.30 (7.13 – 7.47)	7.69 (7.51 – 7.86)	0.410	<0.001
Weekend day/non-workday (h/day)	Hours of sleep at night on a weekend day/non-workday	8.36 (8.17 – 8.55)	8.18 (7.90 – 8.47)	0.272	0.006
Total sleep (h/day)	Mean hours of sleep at night on a weekday/workday and on a weekend day/non-workday	7.83 (7.68 – 7.98)	7.81 (7.65 – 7.97)	0.343	<0.001
Sedentary behaviour					
Weekday/workday (h/day)	Hours of SB on a weekday/workday	8.81 (8.42 – 9.21)	9.81 (9.54 – 10.07)	0.357	<0.001
Weekend day/non-workday (h/day)	Hours of SB on a weekend day/non-workday	8.35 (7.76 – 8.93)	9.39 (9.02 – 9.77)	0.404	<0.001
Total SB (h/day)	Mean hours of SB on a weekday/workday and on a weekend day/non-workday	8.59 (8.18 – 9.00)	9.61 (9.34 – 9.87)	0.428	<0.001
Light PA					
Week/workday (h/day)	Hours of aerobic light PA + strength light PA on a weekday/workday	5.40 (4.79 – 6.02)	5.10 (4.83 – 5.37)	0.331	<0.001

Movement Behaviour variable	Questionnaire variable description	Questionnaire data	Accelerometer data	rho	p
		Mean minutes/hours (95% CI)	Mean minutes/hours (95% CI)		
Weekend/non-workday (h/day)	Hours of aerobic light PA + strength light PA on a weekend day/non-workday	4.48 (3.91 – 5.04)	5.10 (4.77 – 5.43)	0.248	0.013
Total Light PA (h/day)	Mean hours of aerobic light PA + strength light PA on a weekday/workday and on a weekend day/non-workday	4.95 (4.45 – 5.45)	5.15 (4.89 – 5.41)	0.310	0.002
Aerobic Moderate and Vigorous PA					
Aerobic moderate PA (min/day)	Average min per day of aerobic moderate PA in minutes	39.25 (27.39 – 51.11)	39.45 (34.43 – 42.46)	0.500	<0.001
Aerobic vigorous PA (min/day)	Average min per day of aerobic vigorous PA in minutes	16.52 (8.52 – 24.52)	2.24 (1.39 – 3.09)	0.570	<0.001
Aerobic MVPA (min/day)	Sum of calculated aerobic moderate PA and vigorous PA mins per day	55.77 (36.60 – 74.94)	40.67 (36.23 – 45.10)	0.534	<0.001
Total PA					
Total aerobic PA (min/day)	Sum of average min per day of light PA and aerobic MVPA	353.02 (314.34 – 391.70)	349.82 (333.51 – 366.12)	0.372	<0.001

Movement Behaviour variable	Questionnaire variable description	Questionnaire data	Accelerometer data	rho	p
		Mean minutes/hours (95% CI)	Mean minutes/hours (95% CI)		
Total aerobic and strength PA (min/day)	Sum of average min per day of light PA and aerobic and strength PA	387.26 (345.44 – 429.09)	383.95 (365.18 – 402.71)*	0.429	<0.001

Legend: SD: Standard Deviation; CI: Confidence Interval; rho: Spearman Correlation; p: p-value; PA: Physical Activity; MVPA: Moderate to Vigorous Physical Activity; *Strength PA was compared against diary.

Table 7. Validity of movement behaviours from the QMov24h variables against diary (n=117)

Movement Behaviour variable	Questionnaire variable description	Questionnaire data	Diary data	rho	p
		Mean minutes/hours (95% CI)	Mean minutes/hours (95% CI)		
Naps					
Week/workday (h/day)	Hours of naps on a weekday/workday	0.18 (0.09 – 0.27)	0.01 (0.00 – 0.02)	0.367	<0.001
Weekend/non-workday (h/day)	Hours of naps on a weekend day/non-workday	0.22 (0.10 – 0.34)	0.27 (-0.24 – 0.77)	0.232	0.012
Both (h/day)	Mean hours of naps on a weekday/workday and on a weekend day/non-workday	0.20 (0.10 – 0.30)	0.01 (0.00 – 0.02)	0.355	<0.001
Strength moderate PA (min/week)	Sum of all min per day of strength moderate PA	137.12 (104.66 – 169.70)	140.51 (102.15 – 178.87)	0.850	<0.001
Strength moderate PA (times/week)	Sum of the number of days with moderate strength exercise reported	2.71 (2.21 – 3.21)	2.57 (2.09 – 3.05)	0.889	<0.001
Strength vigorous PA (min/week)	Sum of all min per day of strength vigorous PA	95.73 (65.88 – 125.57)	110.76 (83.11 – 138.43)	0.966	<0.001
Strength vigorous PA (times/week)	Sum of the number of days with vigorous strength exercise reported	1.92 (1.46 – 2.38)	1.85 (1.39 – 2.31)	0.910	<0.001
Strength MVPA (min/week)	Sum of calculated strength moderate PA and vigorous PA	241.75 (189.88 – 293.62)	236.24 (184.08 – 288.40)	0.878	<0.001

Movement Behaviour variable	Questionnaire variable description	Questionnaire data	Diary data	rho	p
		Mean minutes/hours (95% CI)	Mean minutes/hours (95% CI)		
	minutes per week				
Strength (times/week)	MVPA Sum of the number of days with moderate or vigorous strength exercise reported	3.35 (2.85 – 3.85)	3.13 (2.65 – 3.61)	0.899	<0.001
Balance activity (min/week)	Sum of all min per day of balance activities	64.31 (29.36 – 99.27)	41.34 (20.01 – 62.66)	0.795	<0.001
Balance (times/week)	activity Sum of the number of days with balance activities reported	1.22 (0.81 – 1.63)	0.79 (0.47 – 1.12)	0.731	<0.001

Legend: SD: Standard Deviation; CI: Confidence Interval; rho: Spearman Correlation; p: p-value; PA: Physical Activity MVPA: Moderate to Vigorous Physical Activity.

Table 8. Test-retest reliability (7 days apart) of movement behaviours variables from the QMov24h (n=117)

Movement Behaviour variable	T1	T2	ICC (95% CI)	p
	Mean minutes/hours/months (95% CI)	Mean minutes/hours/months (95% CI)		
Nocturnal sleep				
Week/workday (h/day)	7.26 (7.11 – 7.42)	7.21 (7.05 – 7.37)	0.788 (0.71 – 0.85)	<0.001
Weekend/non-workday (h/day)	8.36 (8.19 – 8.53)	8.36 (8.19 – 8.53)	0.775 (0.69 – 0.84)	<0.001
Both (h/day)	7.81 (7.68 – 7.95)	7.78 (7.65 – 7.91)	0.776 (0.69 – 0.84)	<0.001
Naps				
Week/workday (h/day)	0.18 (0.09 – 0.27)	0.21 (0.10 – 0.31)	0.643 (0.52 -0.74)	<0.001
Weekend/non-workday (h/day)	0.22 (0.10 – 0.34)	0.24 (0.13 – 0.36)	0.710 (0.61 -0.79)	<0.001
Both (h/day)	0.20 (0.10 – 0.30)	0.20 (0.10 – 0.30)	0.750 (0.66 – 0.82)	<0.001
Patterns of sleep (Months; n=81)	49.53 (34.94 – 64.13)	43.35 (30.17 – 56.52)	0.896 (0.84 – 0.93)	<0.001
Sedentary behaviour				
Week/workday (h/day)	8.62 (8.22 – 9.02)	8.39 (7.97 – 8.82)	0.875 (0.82 – 0.91)	<0.001
Weekend/non-workday (h/day)	8.04 (7.44 – 8.64)	7.63 (7.12 – 8.15)	0.748 (0.65 – 0.82)	<0.001
Both (h/day)	8.34 (7.91 – 8.77)	7.99 (7.58 – 8.39)	0.797 (0.71 – 0.86)	<0.001
Sedentary behaviour on work	5.07 (4.61 – 5.54)	5.17 (4.73 – 5.60)	0.927 (0.90 – 0.95)	<0.001
Sedentary behaviour on leisure	3.25 (2.81 – 3.69)	3.07 (2.61 – 3.53)	0.811 (0.74 – 0.87)	<0.001
Patterns of sedentary behaviour (Months; n=66)	38.00 (23.42 – 54.58)	38.63 (24.03 – 53.24)	0.962 (0.94 – 0.98)	<0.001

Movement Behaviour variable	T1	T2	ICC (95% CI)	p
	Mean minutes/hours/months (95% CI)	Mean minutes/hours/months (95% CI)		
Light PA				
Week/workday (h/day)	5.24 (4.68 – 5.80)	5.19 (4.67 – 5.71)	0.844 (0.78 – 0.89)	<0.001
Weekend/non-workday (h/day)	4.50 (3.96 – 5.03)	4.35 (3.84 – 4.87)	0.833 (0.77- 0.88)	<0.001
Both (h/day)	4.88 (4.41 – 5.35)	4.77 (4.31 – 5.23)	0.840 (0.78 – 0.87)	<0.001
Patterns of light PA (Months; n=71)	35.64 (22.28 – 49.01)	30.60 (18.83 – 42.37)	0.869 (0.80 – 0.91)	<0.001
Aerobic moderate PA (min/day)	40.17 (29.58 – 50.76)	40.59 (31.08 – 50.10)	0.827 (0.76 – 0.88)	<0.001
Strength moderate PA (min/week)	137.18 (104.66 – 169.70)	149.87 (110.94 – 188.80)	0.726 (0.63 – 0.80)	<0.001
Strength moderate PA (times/week)	2.71 (2.21 – 3.21)	2.62 (2.12 – 3.13)	0.891 (0.85 – 0.92)	<0.001
Aerobic vigorous PA (min/day)	17.80 (10.70 – 24.91)	12.31 (8.18 – 16.45)	0.717 (0.61 – 0.80)	<0.001
Strength vigorous PA (min/week)	95.73 (65.88 – 125.57)	72.10 (48.01 – 96.20)	0.812 (0.73 – 0.87)	<0.001
Strength vigorous PA (times/week)	1.92 (1.46 – 2.38)	1.73 (1.29 – 2.17)	0.824 (0.76 – 0.88)	<0.001
Aerobic MVPA (min/day)	55.97 (41.01 – 74.93)	52.91 (40.60 -65.21)	0.820 (0.75 – 0.87)	<0.001
Strength MVPA (min/week)	241.75 (189.88 – 293.62)	221.37 (175.45 – 268.49)	0.748 (0.66 – 0.82)	<0.001
Strength MVPA (times/week)	3.35 (2.85 – 3.85)	3.14 (2.64 – 3.63)	0.835 (0.77 – 0.88)	<0.001
Aerobic and strength MVPA (min/day)*	92.51 (70.63 – 114.39)	84.68 (68.58 -100.65)	0.801 (0.73 – 0.86)	<0.001
Total aerobic PA (min/day)	350.75 (315.75 – 385.75)	339.18 (308.23 – 370.13)	0.828 (0.76 – 0.88)	<0.001
Total aerobic and strength PA (min/day)*	385.29 (347.45 – 423.12)	370.89 (338.36 – 403.42)	0.820 (0.75 – 0.87)	<0.001

Movement Behaviour variable	T1	T2	ICC (95% CI)	p
	Mean minutes/hours/months (95% CI)	Mean minutes/hours/months (95% CI)		
Patterns of MVPA (Months; n=69)	34.64 (20.26 – 49.03)	30.53 (16.82 – 44.23)	0.895 (0.84 – 0.93)	<0.001
Balance activity (min/week)	63.76 (29.09 – 98.43)	45.60 (26.00 – 65.19)	0.380 (0.21 – 0.52)	<0.001
Balance activity (times/week)	1.22 (0.81 – 1.63)	1.12 (0.72 – 1.52)	0.730 (0.63 – 0.80)	<0.001
Patterns of balance activity (Months; n=51)	34.64 (20.53 – 49.03)	30.53 (16.82 – 44.23)	0.895 (0.84 – 0.93)	<0.001

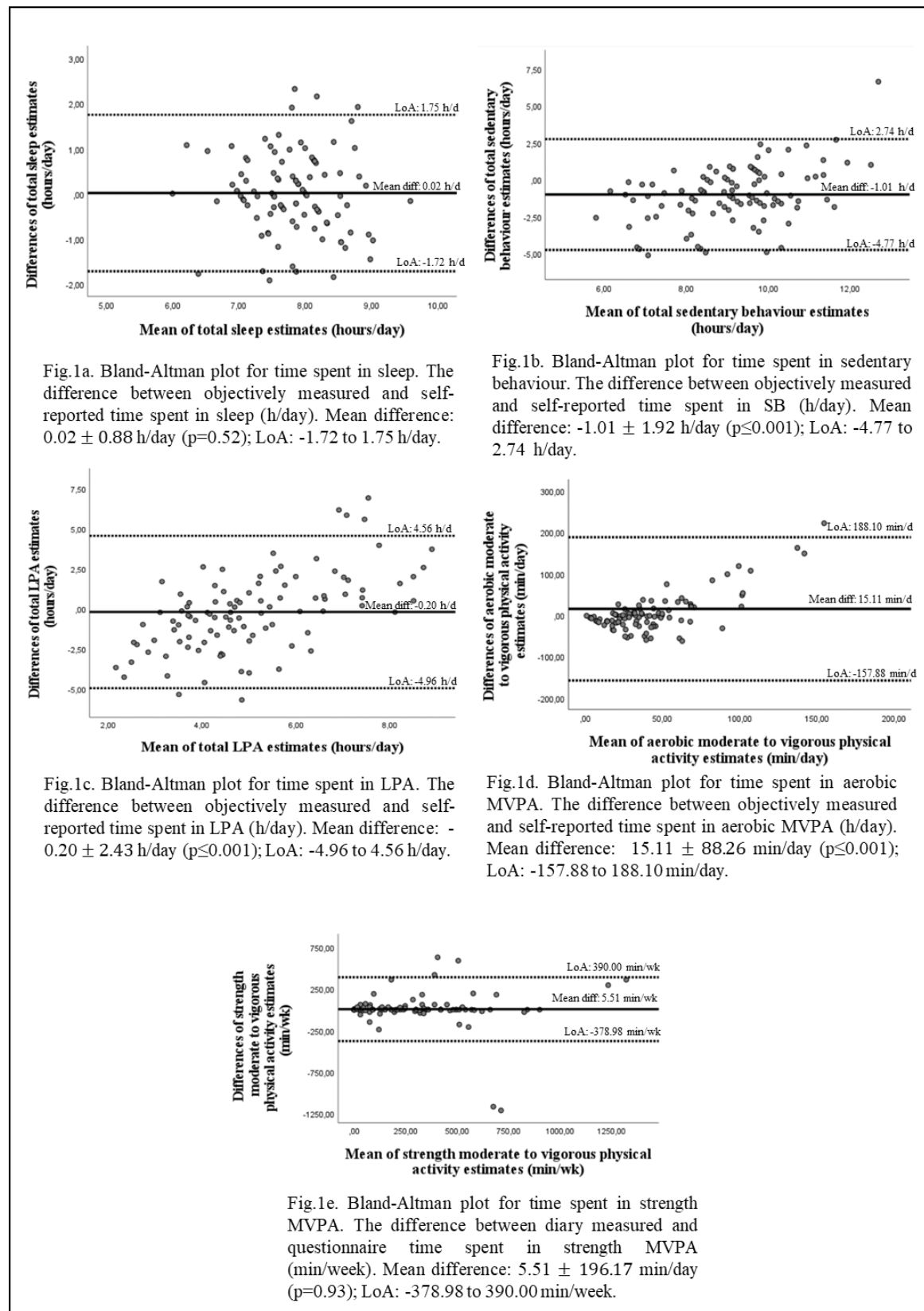
Legend: SD: Standard Deviation; CI: Confidence Interval; ICC: Intraclass correlation; p: p-value; PA: Physical Activity; MVPA: Moderate to Vigorous Physical Activity; * Mean of minutes per day of aerobic MVPA + (Mean of minutes per week of strength MVPA / 7).

Table 9. Percentage of agreement between the compliance with the Canadian 24h movement guidelines and the from the QMov24h data (dichotomized)

	Validity ^a	Reliability ^b
	% of agreement	Kappa (p-value; % of agreement)
Compliance with sleep guidelines	69%	0.38 (p=<0.001; 80.3%)
Compliance with SB guidelines	75.8%	0.70 (p=<0.001; 85.3%)
Compliance with aerobic MVPA guidelines	81.2%	0.87 (p=<0.001; 94,0%)
Compliance with strength MVPA guidelines	94.3%	0.74 (p=<0.001; 88.0%)

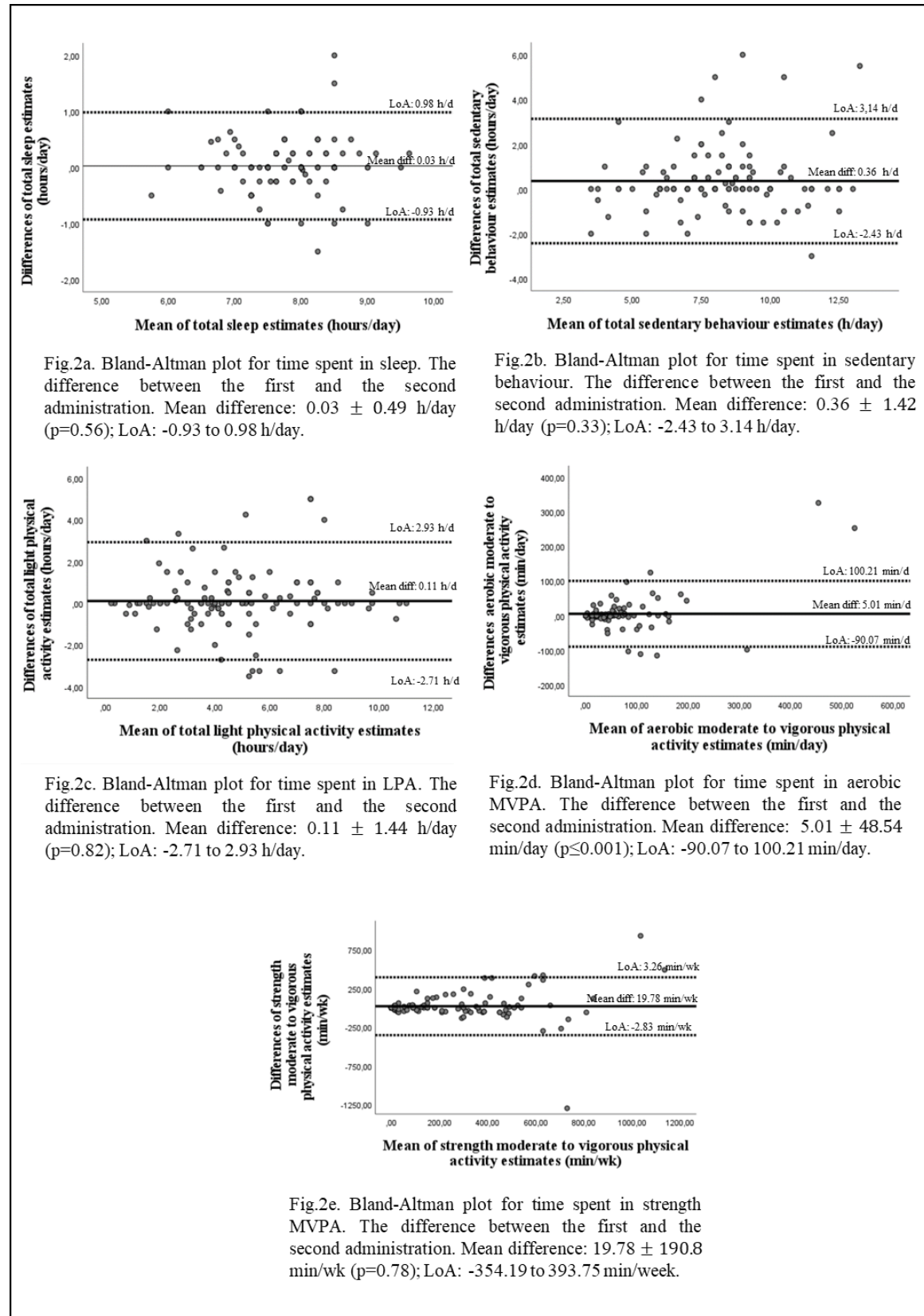
a: Comparing questionnaire with accelerometer; b: Comparing first questionnaire with second questionnaire

Figure 2. Bland Altman plots for validity (QMov24h against accelerometer or diary)



Legend: Legend: LPA: Light Physical Activity; MPA; Moderate Physical Activity; VPA: Vigorous Physical Activity; MVPA: Moderate to Vigorous Physical Activity; h: Hours; d: Day; min: Minutes; wk: Week

Figure 3. Bland Altman plots for reliability (first against second administration of from the QMov24h)



Legend: Legend: LPA: Light Physical Activity; MPA; Moderate Physical Activity; VPA: Vigorous Physical Activity; MVPA: Moderate to Vigorous Physical Activity; h: Hours; d: Day; min: Minutes; wk: Week

6.2. Supplementary files

6.2.1. Supplementary file 1 – 24-hour Movement Questionnaire (QMov24h)

Questionário 24 horas Movimento

O dia tem 24 horas e durante este tempo podemos estar a **dormir, em comportamento sedentário ou em atividade física**. Nas 24h do dia só podemos fazer um destes comportamentos de cada vez. Neste questionário gostaríamos de saber como é que passa o seu tempo habitualmente. Assim, considere, **todos os contextos e momentos em que estes comportamentos ocorrem, seja no trabalho/a estudar, no tempo livre, ou como forma de deslocamento**. Não importa se apenas anda de carro para o trabalho durante 5 minutos, ou se costuma estar sentado/a apenas 10 minutos no autocarro; queremos saber esses pequenos momentos, por favor, tente contabilizá-los todos. Neste questionário consideramos **dias de trabalho/estudo** (normalmente dias de semana) e **dias em que não trabalha** (normalmente ao fim de semana, ou nos dias de folga do trabalho), numa semana típica.

Não existem respostas certas ou erradas. Por favor, responda a cada pergunta de forma precisa e sincera.

Como responder a este questionário?

Vamos perguntar-lhe **quanto tempo passa a dormir, em comportamento sedentário e em atividade física**. Assim, por favor, responda às questões desta forma:

EXEMPLOS:

Imagine que passa 35 minutos num determinado comportamento ou atividade:

Em média, quanto tempo passa ..., por dia?	<u>0</u> h <u>35</u> min, por dia

Imagine que passa 1 hora e 5 minutos num determinado comportamento ou atividade:

Em média, quanto tempo passa ..., por dia?	<u>1</u> h <u>05</u> min, por dia

Dias de trabalho/estudo e dias de folga

Indique por favor, numa semana típica, os dias em que trabalha e os seus dias de folga do trabalho (dias em que não trabalha). Se não tem um padrão de dias de trabalho e de folgas fixo, reporte nesta questão, os dias em que trabalhou e esteve de folga na semana passada.

Se for reformado/a, não responda a esta questão e continue a responder na secção 1.

Se for estudante, considere como dias de trabalho os dias em que estuda ou tem aulas.

	2ª feira	3ª feira	4ª feira	5ª feira	6ª feira	Sábado	Domingo
Dias de trabalho	☐	☐	☐	☐	☐	☐	☐
Dias em que não trabalha (folgas)	☐	☐	☐	☐	☐	☐	☐

Secção 1. Sono Noturno e Sestas



O **sono** noturno é o tempo que dorme durante a noite. Se trabalhar por turnos, ou trabalhar durante a noite, ou se tiver padrões de sono variáveis, tente estimar o número médio de horas no seu período de sono mais longo. As **sesta**s são momentos em que dorme durante o dia.

Numa <u>semana típica</u> , ...	num dia de semana ou de trabalho	num dia de fim-de-semana ou em que <u>não</u> trabalha
1. Em média, quanto tempo passa a dormir (sono noturno), por dia? <i>(Não inclua o tempo que passa deitado/a sem estar a dormir)</i>	____ h ____ min, por dia	____ h ____ min, por dia
2. Em média, quanto tempo passa a fazer a(s) sesta(s) , por dia?	____ h ____ min, por dia	____ h ____ min, por dia
Se não faz sesta(s) assinale com um ✓ aqui ☐		

Há quanto tempo mantém este padrão de sono? _____ semanas/meses/anos (riscar o que não interessa).

Secção 2. Comportamento Sedentário



O **comportamento sedentário** é o tempo que passa **sentado/a, reclinado/a ou deitado/a, enquanto está acordado/a**, em que gasta pouca energia. Durante este tempo pode estar a comer, a ler, a estudar, a ver televisão, a trabalhar no computador/tablet, a conduzir, sentado nos transportes públicos, na missa, a jogar xadrez, ou noutras atividades, desde que esteja sentado/a, reclinado/a ou deitado/a enquanto acordado.

Nas perguntas seguintes, **contabilize todos os momentos em que está sentado/a, reclinado/a ou deitado/a e acordado/a, desde o momento em que acorda até que adormece.**

Numa <u>semana típica</u> , ...	num dia de semana ou de trabalho	num dia de fim-de-semana ou em que <u>não</u> trabalha
3. Em média, quanto tempo passa sentado/a, reclinado/a ou deitado/a , por dia?	____ h ____ min, por dia	____ h ____ min, por dia
3.1. Do tempo que indicou na questão 3, quanto tempo, em média por dia, passa sentado/a, enquanto trabalha?	____ h ____ min, por dia	
3.2. Do tempo que indicou na questão 3, quanto tempo, em média por dia, passa sentado/a, no tempo em que não está a trabalhar?	____ h ____ min, por dia	

Há quanto tempo mantém este padrão de comportamento sedentário? _____ semanas/meses/anos (riscar o que não interessa).

Secção 3. Atividade Física

A atividade física é qualquer movimento que realiza recorrendo aos seus músculos. Existem muitas formas de atividade física, entre as quais:

Aeróbias: atividades em que utiliza os grandes grupos musculares de forma repetida e dinâmica.

(ex.: andar a pé/correr, andar de bicicleta, dançar, jogar futebol ou outro jogo coletivo, etc.)



Fortalecimento Muscular: atividades que requerem o uso da força dos músculos.

(ex.: estar de pé, pegar em compras, segurar uma criança ao colo, levantar objetos, arrastar móveis, agachamentos, levantar pesos, exercícios com bandas elásticas ou máquinas de musculação, etc.)



As atividades aeróbias e de fortalecimento muscular podem ser de intensidade ligeira, moderada ou vigorosa:

Atividades Ligeiras



- baixa intensidade
- requerem um esforço mínimo



- batimentos cardíacos ligeiramente superiores aos de repouso
- respiração ligeiramente superior à de repouso



- é possível conversar normalmente



- depois de as realizar não se sente cansado/a

Atividades Moderadas



- intensidade média
- requerem mais esforço do que as atividades ligeiras



- batimentos cardíacos superiores ao das atividades ligeiras
- respiração acelerada



- é possível conversar, mas com alguma dificuldade



- transpira
- depois de as realizar sente-se cansado/a

Atividades Vigorosas



- intensidade elevada
- requerem muito esforço



- batimentos cardíacos superiores ao das atividades moderadas
- respiração ofegante



- não é possível conversar



- transpira mais
- depois de as realizar sente-se muito cansado/a

Nota importante:

A mesma atividade pode requerer esforços de intensidades diferentes em pessoas diferentes. Por exemplo, caminhar pode representar para si um esforço aeróbio mínimo, em que consegue manter uma conversa. Neste caso deve considerá-la de intensidade ligeira. Mas, se caminhar for para si uma atividade muito difícil de realizar, cansando-se e exigindo um esforço muito elevado, deve considerá-la uma atividade aeróbia vigorosa. Numa escala de esforço de 1 a 10, um esforço mínimo é 1 e um esforço máximo é 10:

Atividade ligeira			Atividade moderada			Atividade vigorosa			
1	2	3	4	5	6	7	8	9	10

Esforço mínimo

Esforço máximo

Secção 3a. Atividade Física Ligeira



Estime o tempo médio por dia em que faz atividades LIGEIRAS aeróbias e de fortalecimento muscular.

Numa <u>semana típica</u> , ...	num dia de semana ou de trabalho	num dia de fim-de-semana ou em que <u>não</u> trabalha
4. Em média, quanto tempo passa em <u>atividade aeróbia ligeira</u> , por dia?	____ h ____ min, por dia	____ h ____ min, por dia
5. Em média, quanto tempo passa em <u>atividade de fortalecimento muscular ligeira</u> , por dia?	____ h ____ min, por dia	____ h ____ min, por dia

Há quanto tempo mantém este padrão de atividade física ligeira? _____ semanas/meses/anos (riscar o que não interessa).

Secção 3b. Atividade Física Moderada e Vigorosa

Nas perguntas seguintes, referentes à atividade moderada e vigorosa, pedimos-lhe que estime o tempo em que faz atividade física da respetiva intensidade em cada um dos dias da semana (semana típica).

EXEMPLO:

Imagine que faz uma caminhada de 30 minutos à 2ª feira e uma sessão de atividade física de 1 hora à 5ª feira. Suponha que para si essa caminhada representa uma atividade aeróbia moderada. Na sessão de atividade física a intensidade do esforço e o tipo de atividade física podem variar; nestes casos estime o tempo passado em cada tipo e intensidade de atividade. Suponha que durante a sessão de atividade física fez cerca de 5 minutos de aquecimento (esforço aeróbio ligeiro), 25 min em esforço aeróbio moderado, 20 minutos de fortalecimento muscular moderado e 10 min de fortalecimento muscular vigoroso. De acordo com este exemplo deveria responder assim:

	ATIVIDADES MODERADAS		ATIVIDADES VIGOROSAS	
	Aeróbias	Fortalecimento muscular	Aeróbias	Fortalecimento muscular
2ª feira	____ h <u>25</u> min	____ h ____ min	____ h ____ min	____ h ____ min
3ª feira	____ h ____ min	____ h ____ min	____ h ____ min	____ h ____ min
4ª feira	____ h ____ min	____ h ____ min	____ h ____ min	____ h ____ min
5ª feira	____ h <u>30</u> min	____ h <u>20</u> min	____ h ____ min	____ h <u>10</u> min
6ª feira	____ h ____ min	____ h ____ min	____ h ____ min	____ h ____ min
Sábado	____ h ____ min	____ h ____ min	____ h ____ min	____ h ____ min
Domingo	____ h ____ min	____ h ____ min	____ h ____ min	____ h ____ min

Estime o tempo médio por cada dia da semana em que faz **atividades de intensidade MODERADA e VIGOROSA** aeróbias e de fortalecimento muscular, numa **semana típica**.

ATIVIDADES MODERADAS 		ATIVIDADES VIGOROSAS 	
Aeróbias	Fortalecimento muscular	Aeróbias	Fortalecimento muscular
2ª feira	_____ h _____ min	_____ h _____ min	_____ h _____ min
3ª feira	_____ h _____ min	_____ h _____ min	_____ h _____ min
4ª feira	_____ h _____ min	_____ h _____ min	_____ h _____ min
5ª feira	_____ h _____ min	_____ h _____ min	_____ h _____ min
6ª feira	_____ h _____ min	_____ h _____ min	_____ h _____ min
Sábado	_____ h _____ min	_____ h _____ min	_____ h _____ min
Domingo	_____ h _____ min	_____ h _____ min	_____ h _____ min

Se não faz atividades **moderadas** assinale com um ✓ aqui ☐ Se não faz atividades **vigorosas** assinale com um ✓ aqui ☐

Há quanto tempo mantém este padrão de atividade física moderada e vigorosa? _____ semanas/meses/anos (riscar o que não interessa).

Secção 3c: Atividades de Equilíbrio



As **atividades de equilíbrio** são aquelas em que desafia a sua capacidade de se manter estático (sem se mexer) ou que desafia a sua capacidade de equilíbrio enquanto se movimenta, como por exemplo, estar durante alguns segundos apenas com um pé no chão, estar durante alguns segundos parado na ponta dos pés, andar na ponta dos pés, alguns exercícios de Tai Chi Chuan, Yoga ou Pilates, etc.

Estime o tempo médio por cada dia da semana em que faz **atividades de equilíbrio**, numa **semana típica**.

2ª feira	_____ h _____ min
3ª feira	_____ h _____ min
4ª feira	_____ h _____ min
5ª feira	_____ h _____ min
6ª feira	_____ h _____ min
Sábado	_____ h _____ min
Domingo	_____ h _____ min

Se não faz atividades de equilíbrio assinale com um ✓ aqui ☐

Há quanto tempo mantém este padrão de atividades de equilíbrio? _____ semanas/meses/anos (riscar o que não interessa).

Agradecemos a sua colaboração!

Chapter 7

7.1. Study 4 (Paper IV) – Methodological Choices on 24-hour Movement Behaviour Assessment by Accelerometry: a Scoping Review

(Submitted to Journal of Sport and Health Science)

Methodological Choices on 24-hour movement behaviour assessment by accelerometry: a scoping review

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Abstract

Background: With the launch of 24-hour movement behaviours guidelines, there is a need to understand how to accurately assess 24-hour movement behaviors using accelerometry. We aim to synthesise information on methods for assessing 24-hour movement behaviours using accelerometry across all age groups.

Methods: PubMed, PsycINFO, SPORTDiscus, and EMBASE were searched until December 2022. Observational or intervention reports describing accelerometry methods in studies on combinations of movement behaviours, with a 24-hour protocol across all ages, were included.

Results: This review included 102 studies (72 were cross-sectional, 21 longitudinal, 6 RCTs and 3 non-RCT interventions). Three studies in toddlers, 15 in preschoolers, 17 in children, 23 in adolescents and 44 in adults and older adults. The Actigraph GT3X was the most commonly used device; the majority of the included reports collected data for seven days, including three weekdays and one weekend day, with at ≥ 16 h/day per 24-hour period for valid data. Non-wear time criteria varied between ≥ 20 and ≥ 90 min of consecutive zero counts, depending on age the age group being considered. The most common epoch used was 15 or 60 seconds for youth and adults, respectively. The choice of sleep algorithms and SB/PA cut-points, of the included reports, depended on age and the original validation/calibration study. To deal with non-compliant participants, exclusion of non-compliant participants from the analysis was most frequently used. Most studies used diaries/logs to complement the accelerometer data.

Conclusions: Accelerometer protocols and methodological decisions varied considerably between reports. Therefore, consensus on methodological decisions is needed to improve precision and comparability between studies, which is challenging given the complexity of the procedures, the number of available brands and types of accelerometers, and the plethora of programming options.

1. Introduction

The health benefits of achieving an adequate distribution of all three 24-hour movement behaviours (MovBeh) [i.e., adequate levels of sleep, sedentary behaviour (SB) and physical activity (PA)] have been described¹⁻⁵. It is also known that the association between one MovBeh and health, may depend on the levels of the other behaviors⁶. This has led to the development of several country-specific 24-hour movement guidelines for different age groups⁷⁻¹¹, and to the World Health Organization (WHO) guidelines for young children¹². As these new guidelines integrate all MovBeh, from a research and public health perspective, there is a need to adapt the current monitoring and surveillance tools, to accurately measure 24-hour MovBeh in an integrated manner in order to assess guideline adherence, health associations, correlates and determinants, as well as the effectiveness and efficacy of interventions to promote 24-hour MovBeh¹³.

MovBeh can be measured by device-based methods such as accelerometry, which generally have advantages over self-report measures because of their greater accuracy¹⁴⁻²² and also because they can assess all three MovBeh concurrently over consecutive 24-hour periods. Other objective instruments such as, doubly labelled water, direct and indirect calorimetry, and direct observation of PA and SB, and polysomnography for sleep are currently in use; however, these do not assess all three MovBeh over 24-hour periods in free-living conditions, and each has several limitations^{15,23}.

Despite the limitations of accelerometry (e.g., they do not correctly measure muscle-strengthening exercises), they can detect body (non)movement (i.e., amount and intensity), continuously and over extended periods of time in free-living conditions; therefore, they have become one of preferred methods to assess 24-hour MovBeh²⁴. Nevertheless, data collection and processing methods depend on individual decisions made by researchers (e.g. accelerometer brand/model and device placement, cut points or algorithms applied, data reduction performed, criteria for non-wear time, number and criteria of valid days required, etc.), which are necessary to collect and transform the data into estimates of MovBeh²³, thus preventing meaningful comparisons between studies²⁵. In addition, there are unique challenges in standardising 24-hour accelerometry, such as distinguishing between SB,

sleep and non-wear time, and the best place on the body to attach the accelerometer. It is therefore important to standardise methodological decisions using consensus guidelines for the collection and processing of accelerometer data. Different methodological choices for processing the same data can result in significantly different values for the same variables. This has important limitations, particularly in large-scale epidemiological studies, such as generalisability, validity, and sustainability, which are intended to be comparable²⁵.

There is an overwhelming amount of information on accelerometry methodologies. Several reviews have summarised accelerometer measurement properties²⁶⁻²⁸, analytical approaches²⁹, best practices in selecting and applying accelerometers to quantify the 24-hour MovBeh^{24,30}, methodological choices (e.g., epoch length, wear site, cut-points) for assessing PA in young children³¹ and MovBeh in elderly³², or across the lifespan, but were specific to a particular brand and focused on validation and calibration studies³³. However, none of the previous reviews described current measurement protocols and accelerometer processing decisions to be used in 24-hour MovBeh studies, across the lifespan. Therefore, we aim to synthesize the information on the methods used to assess 24-hour movement behaviours using accelerometers, across all age groups.

2. Methods

This review is reported in accordance with the PRISMA extension for Scoping Reviews guidelines³⁴. The protocol is publicly available in the Open Science Framework repository (OSF Repository Files). The current scoping review is consistent with the methodology proposed by Arksey and O'Malley³⁵ and later updated by Levac et al³⁶. Scoping reviews have been given little attention when compared with other types of reviews, such as the systematic reviews. Nevertheless, scoping reviews might be more appropriate when the research question is broader, and the aim does not comprise the evidence systematizing nor the studies quality assessment, such as in this study³⁶.

2.1. Eligibility Criteria

Inclusion criteria: 1) reports with babies, toddlers, children, adolescents, adults and older adults, non-pregnant, without disease at baseline, in free-living conditions; 2) observational and intervention reports that reported accelerometry methods for MovBeh combinations (sleep, SB, PA); 3) Studies in which participants were asked to wear accelerometers 24 hours per day; 4) reports written in English, Spanish, French, Portuguese, German, or Italian.

Exclusion criteria: 1) reports conducted solely with clinical populations (e.g., established chronic disease(s), motor diseases, auto-immune diseases, infectious diseases, sleep disorders, cognitive impairment, etc.); 2) reports evaluating just one or two MovBeh; 3) reports evaluating just one or two MovBeh with accelerometry and the remaining with another method, such as self-report; 4) grey literature (e.g. thesis, book chapters), case-reports, editorials, conference abstracts, methods papers, reviews, meta-analyses, validation reports, commentaries, cost-effectiveness reports and qualitative reports; 5) when multiple reports were published based on the same study and used the same accelerometer procedures, we included the study with the largest sample size.

2.2. Information Sources and Search Strategy

Four electronic databases were searched from inception to December 2022: PubMed, EMBASE, PsycINFO and SPORTDiscus. Additional reports were identified by manually searching references from the included reports and authors' personal libraries.

The databases were searched for variants of the following terms: 'movement behaviours', 'sleep', 'sedentary behaviour', 'physical activity', 'accelerometer' and 'measurement properties' (for a detailed search strategy see Additional file 1). The search terms were adjusted for each specific electronic database to ensure the quality of the systematic searching.

2.3. Study Selection Process

Two authors (BR; AVS) independently selected potentially relevant reports based on titles, abstracts, and full texts. Disagreements were discussed with a third author (RS). The study selection process was conducted through CADIMA software³⁷.

2.4. Data charting process

A standardized data extraction sheet was built to chart relevant information from the included reports. It included country, study name, type of study, participants' age and gender and corresponding results: accelerometer brand/model; accelerometer placement on the body; software used for data reduction and analysis; number of days for data collection; number of required valid days, and time required to be considered as a valid 24-hour period; non-wear time criteria; epoch length and data reduction (epoch integration); MovBeh outcome (i.e., sleep, light PA and moderate-to-vigorous PA, etc.) and reporting formats (e.g., minutes/day, steps/minutes, etc.); sleep measuring procedure and PA and SB cut-points used; procedures for identifying and handling non-compliant participants; log or diary use.

The data were collected independently by 2 authors (BR; AVS) and disagreements were resolved by discussion with another author (RS).

2.5. Synthesis of results

A high-level summary of findings table was created to present total counts of each variable collected in all reports. Additionally, two narrative sub-analysis were carried out: 1) the most used procedures, and 2) the most used cut-points and algorithms depending on the body placement and the accelerometer brand.

3. Results

3.1 Search Results

The search yielded 2,000 records after removing duplicates. Of these, 1,720 were excluded based on title and abstract, leaving 280 records for full-text screening. One hundred and two reports met eligibility criteria and were included. The flow diagram and the reasons for full texts' exclusion are described in figure 1.

-----Insert Figure 1-----

3.1. Reports' characteristics

Of the 102 reports included, 72 were cross-sectional, 21 longitudinal, 6 RCTs and 3 non-RCT interventions. Overall, this review included 140,643 participants (~55% female). Ninety-four reports included both genders, seven reports included only girls/women and one study included only boys/men. Regarding the age groups, this review included three reports with toddlers³⁸⁻⁴⁰, 15 reports with preschoolers⁴¹⁻⁵⁵, 17 reports with children⁵⁶⁻⁷², 22 reports with adolescents⁷³⁻⁹³ and 44 reports with adults and older adults⁹⁴⁻¹³⁸. The most represented countries were the United States of America ($n=32$), Australia ($n=10$) and Spain ($n=9$). The summary of reports' characteristics is presented in table 1.

--- Insert table 1---

3.2. Synthesis of the results

The results of each report, by age group, are presented in Additional file 2 and the high-level summary of findings on accelerometer methods and procedures are presented in table 2.

3.2.1. Infants, toddlers, and pre-schoolers

This review included 18 reports³⁸⁻⁵⁵ with toddlers and pre-schoolers (aged 2-5 years). There were no reports with infants (0-2 years). Eight different accelerometers or combinations (of accelerometers) were used. The most used accelerometer was the Actigraph GT3X (11 reports out of 18; 61.1%)^{39,40,42,43,45-47,51-54}. Overall, 10 reports placed the accelerometer on the hip (55.6%)^{39,42,45-48,50,53-55}, four on the wrist (22.2%)^{40,41,43,49} and one on the ankle (5.6%)³⁸. The

remaining reports (16.7%) placed the accelerometers in two different sites simultaneously^{44,51,52}.

The number of data collection days varied substantially between reports (3 to 16 days), with the most frequent being 7 days (50%)^{39,40,42-44,47,48,51,54}. Out of the 18 reports, Three reports (16.7%) did not report the number of required valid days^{44,45,49}, four (20%) required ≥ 3 weekdays and ≥ 1 weekend day^{38,42,47,51}, and three (17%) required ≥ 3 days^{40,48,54}, whereas the remaining ones (8; 44.4%) varied substantially. Regarding criteria for the 24-hour period to be considered valid, three reports (17%) did not present this information^{40,44,50}, three (17%) considered one 24-h period as a valid day^{38,39,55}, whereas the remaining reports (12; 66.7%) varied substantially.

Two reports (11.1%) did not describe the criteria for non-wear time^{41,44}, and 50% of the reports considered ≥ 20 min of consecutive zero counts as non-wear time^{46-48,50-55}.

Concerning the epoch length, regardless of the sampling rate (ranging from 30 to 87.5 Hertz), the most used epoch length was 15-seconds^{39,42,45-50,52,55} (10; 55.6%). One report (5.6%) used two different epochs depending on which movement behaviour was assessed⁴⁷. Nine reports (50.0%) described the sampling rate^{39,41,43,46,47,49,52-54}.

The most used reporting formats of MovBeh were temporal units such as h/day or min/day (17; 94.4.9%)^{38-43,45-55}. One study (5.6%) used the percentage of time over 24-h⁴⁴.

To assess sleep, nine reports (50%) used different sleep algorithms (table 3) and four reports (22.2%) manually and visually screened sleep data, considering a log and the accelerometer files. To assess PA and SB, the choice of the cut-points varied considerably, with that from Pate et al., 2006¹³⁹ being the most frequently used 4; 22.2%) (table 4).

The most used procedure for handling non-compliant participants was the exclusion of the non-compliant participants from the analysis (17; 94.4%).

Seven reports (38.9%) did not use logs or diaries whereas the remaining (11; 61.1%) used different instruments to complement accelerometer data.

--- Insert tables 2, 3 and 4 ---

3.2.2. Children

This review included 17⁵⁶⁻⁷² reports with children aged 5-10 years. Eight different accelerometers or combinations (of accelerometers) were used. The most used accelerometer was the Actigraph GT3X (8; 47.1%)^{56,58-60,62,63,66,67}. Overall, nine reports placed the accelerometer on the wrist (52.9%)^{57,58,61,64,65,67-69,71} and seven on the hip (41.2%)^{56,59,60,62,66,71,72}. The remaining reports (11.8%) placed the accelerometers in two different sites simultaneously: one on the thigh and lower back⁷⁰, one on the hip and wrist⁷¹.

The number of data collection days varied substantially between reports (3 days to 6 weeks), with the most frequent being 7 days (64.7%)^{56-58,60,62,63,65-67,70,71}. Two reports (11.8%)^{57,64} did not present the number of required valid days, seven (41.2%)^{56,60,61,63,66,68,71} required ≥ 3 weekdays and ≥ 1 weekend day, and three reports (17.7%)^{59,62,65} required ≥ 3 days, whereas the remaining varied substantially (5; 29.4%)^{58,67,69,70,72}. Regarding criteria for the 24-hour period to be considered valid, one reports (5.9%)⁵⁷ did not present this information, three (17%)^{56,61,62} defined that the accelerometer should be used during, at least 10 waking hours, another three reports (17.7%)^{58,65,68} defined the criteria of 16 hours/day, whereas the remaining varied substantially (10; 58.8%)^{59,60,63,64,66,67,69-72}.

Three reports (23.5%)^{61,64,69} did not describe the criteria for non-wear time, three reports (17.7%)^{56,59,62} used ≥ 20 min of consecutive zero counts, whereas the remaining varied substantially (11; 58.8%)^{57,58,60,63,65-68,70-72}.

Concerning the epoch length, regardless of the sampling rate (ranging from 30 to 100 Hertz), the most used epoch length was 1-minute (9; 52.9%)^{56,57,60,63,64,66,67,71,72}. One report (5.9%)⁶⁴ used two different epochs according to the behaviours (8.7%). Eight reports (47.1%)^{56,58,65,67-71} presented the sampling rate.

The most used reporting formats of MovBeh were temporal units such as h/day and min/day (16; 94.1%)^{56-58,60-72}. One report (5.9%)⁵⁹ used the percentage of time over 24 hours.

To assess sleep, this review found 11 different options, with the most used one being that of Sadeh et al., 1994¹⁴⁰ sleep algorithm, (4; 23.5%)^{60,66,67,71}. Fourteen reports (82.4%)^{56-60,62,63,65-71} used sleep algorithms (table 3). To assess PA and SB, the cut-points choice varied considerably, with the Evenson

et al., 2008¹⁴¹ one being the most frequently used (7; 41.2%)^{56,59,60,62,63,70,71} (table 4).

The most used procedure for handling non-compliant participants was the exclusion of the non-compliant participants from the analysis (13; 76.5%)^{56,57,59-61,63,64,66,68-72}.

Nine reports (52.9%)^{56-59,61-64,68} did not use logs or diaries and the remaining reports (8; 47.1%)^{60,65-67,69-72} used different instruments to complement the accelerometer data.

3.2.3. Adolescents

This review included 22 reports^{73-93,142} with adolescents aged 10 to 17 years. Twelve different accelerometers or combinations of accelerometers were used. The most used accelerometer was the Actigraph GT3X (9; 40.9%)^{73,75,77,78,87,89,91,92,142}. Overall, 10 reports placed the accelerometer on the wrist (45.5%)^{74-76,79,81,82,85,86,88,93}, six on the hip (27.3%)^{73,83,87,89,90,142}, one on the chest (4.6%)⁸⁰ and one on the thigh (4.6%)⁸⁴. The remaining reports (4; 18.2%) placed the accelerometers on the hip and wrist^{77,78,91,92}, simultaneously.

The number of data collection days varied substantially between reports (3 to 14 days), with the most frequent one being 7 days (52.2%)^{75,77,79,81,83,85,88,89,91-93,142}. Four reports (18.2%)^{78,82,85,88} did not present the number of required valid days, six reports (27.3%)^{74,75,77,81,86,89} required ≥ 3 weekdays and ≥ 1 weekend day, and five reports (22.7%)^{79,91-93,142} required ≥ 3 days, whereas the remaining varied substantially (7; 31.8%). Regarding criteria for the 24-hour period to be considered valid, eight reports (36.4%)^{73,77,78,83,89,91-93} used the 10 waking hours/day criteria, four reports (18.2%)^{74,75,79,81} defined the criteria as 16 hours/day, whereas the remaining varied substantially (10; 45.5%)

Four reports (18.2%)^{76-78,93} did not present the criteria for non-wear time, four reports (18.2%)^{74,79,81,88} based the criteria on the standard deviation and value range of each axis, using a 60-min window with 15-min increments, and three reports (13.6%)^{73,87,90} used the criteria of ≥ 20 min of consecutive zero counts, whereas the remaining varied substantially (11; 50.0%).

Concerning the epoch length, regardless of the sampling rate (ranging from 30 to 100 Hertz), the most used epoch length was 1-minute (8; 36.4%)^{76,77,85,87,90,91,93,142}. Two reports used two different epochs according to

the behaviours (9.1%)^{77,91}. Thirteen 13 reports (59.1%)^{73-77,79,81,84,86-88,92,142} presented the sampling rate.

The most used reporting formats of MovBeh were temporal units, such as hours/day and minutes/day (20; 95.5%)^{73,75,76,78-93,142}. Two reports (9.1%)^{74,77} also used the percentage of 24 hours.

To assess sleep, this review found 10 different options, and the most used one being the Sadeh et al., 1994¹⁴⁰ sleep algorithm (5; 22.7%)^{77,78,82,87,142}. Fifteen reports (68.2%)^{74-79,81,82,86-89,91,92,142} used sleep algorithms (table 3). To assess PA and SB, the cut-points choice varied considerably, with those from Hildebrand et al 2014¹⁴³ and 2017¹⁴⁴ being the most frequently used ones ($n=3$; 13.6%)^{75,81,88} (table 4).

The most used procedure for handling non-compliant participants was the exclusion of the non-compliant participants from the analysis (17; 77.3%)^{73-75,77,78,80,82,83,85-93}.

Nine reports (40.9%)^{76-78,81,84,86,90,91,142} used logs or diaries for sleep assessment and non-wear time, whereas seven reports did not use logs nor diaries^{74,75,79,87-89,92}, and the remaining used different instruments to complement the accelerometer data (6; 27.3%)^{73,80,82,83,85,93}.

3.2.4. Adults and older adults

This review included 44 reports⁹⁴⁻¹³⁸ for adults and older adults (aged ≥ 18 years). Twenty different accelerometers or combinations of accelerometers were used. The most used accelerometer was the Actigraph GT3X (10; 22.7%)^{101,102,104,107,117,122,125,129,134,138}. In 20 reports the accelerometer was placed on the wrist (45.5%)^{94,95,98,100,101,105-107,110,111,118,120-122,124,129,132,134,138}, five on the arm (11.4%)^{103,108,114,131,133}, six on the thigh (13.6%)^{96,116,117,123,125,136}, and two on the hip (4.6%)^{102,104}. The remaining reports placed the accelerometers in two different sites simultaneously (12; 27.3%)^{97,108,112,113,115,119,126-128,130,135,137}.

The number of data collection days varied substantially between reports (1 to 25 days), with the most frequent one being seven days (28; 63.6%)^{94,96,100-102,106-108,110,111,113-116,118-123,126,128,130-132,135,136,138}. Eight reports (18.2%)^{95,98,104-106,129,132,135} did not present the number of required valid days, 9 reports (20.5%)^{99,101,102,107,111,114,116,122,138} required ≥ 3 weekdays and ≥ 1 weekend day, eight reports (18.2%)^{108,110,113,118,127,128,130,131} required ≥ 4 days, whereas the

remaining varied substantially (19; 43.2%). Regarding criteria for the 24-hour period to be considered valid, 21 reports (47.7%)^{96,102,105,108,110-112,115,116,119-121,123-125,128,130,134,135,137,138} defined that the accelerometer should be used during 10 waking hours and other five reports (11.4%)^{100,101,104,107,122} defined the criteria of 16 hours/day, whereas the remaining varied substantially (19 out of 44; 43.2%)^{94,95,97-99,103,106,109,113,114,117,118,126,127,129,131-133,136}. Five reports (11.4%)^{95,98,129,132,136} did not present the required minutes for a day to be considered valid.

Seventeen reports (38.6%)^{95,97,101,104,107,112,114,120-122,124,128,131-133,137,138} did not present the criteria for non-wear time, four reports (9.1%)^{99,110,118,134} based the criteria on the standard deviation and value range of each axis, using a 60-min window with 15-min increments, and other six reports (13.6%)^{105,116,117,127,130,135} used the criteria of ≥ 60 min of consecutive zero counts, whereas the remaining varied substantially (17; 38.6%).

Concerning the epoch length, regardless of the sampling rate (ranging from 30 to 100 Hertz), the most used epoch length was 1-minute (20; 45.5%)^{94,95,97,102-106,108,109,111,124,126-130,133,135,138}. Two reports used two different epochs according to the behaviours (4.6%)^{119,138}. Twenty-two reports (50%)^{96,98,100,101,104,106-108,110-113,116,118,120,123,124,126-128,132,138} presented the sampling rate, and eight reports (18.2%)^{114,115,117,119,125,134,136,137} did not present the epoch, nor the sampling rate.

The most used reporting formats of MovBeh were temporal units such as hours/day and minutes/day (32; 72.7%)^{94,96,97,100,101,104,106,108,109,113-115,117-135,138}. The remaining reports differed substantially (13; 29.6%)^{95,98,100,102,103,105,107,110-113,116,136,137}, with six using more than one reporting format^{95,102,103,111,112,136} (e.g., percentage of time and steps).

To assess sleep, this review found 19 different options, with the most used one being that from Cole–Kripke et al., 1992¹⁴⁵ sleep algorithm, (9; 20.5%)^{95,104,108,115,119,127,129,135,138}. Thirty reports (68.2%)^{95,96,100,101,104,106,108-110,112,114,115,118-124,126-135,138} used sleep algorithms (table 3). To assess PA and SB, the cut-points choice varied considerably, with the Freedson et al., 1998¹⁴⁶ cut-point being the most frequently used (6; 13.6%)^{95,102,108,126,130,131} (table 4).

The most used procedure for handling non-compliant participants was the exclusion of the non-compliant participants from the analysis (40; 90.9%)^{94-98,101-105,107-128,130,131,133-138}.

Seventeen reports (38.6%)^{95-97,104,113,118-121,126-130,135,137,138} used logs or diaries for sleep, seven reports (15.9%)^{101,102,107,108,111,115,122} used logs and diaries for sleep and non-wear time, other seven reports (15.9%)^{94,99,103,105,106,112,114} did not use logs nor diaries, and the remaining used different instruments to complement the accelerometer data (13; 29.6%)^{98,109,110,116,117,122-125,131-133,136}.

A summary of most commonly used methods and procedures in studies measuring 24-hour MovBeh with accelerometry, across all-age groups are presented in Table 5.

---Insert Table 5---

4. Discussion

This scoping review summarizes the methodological procedures most commonly used to assess 24-hour MovBeh with accelerometry, across the lifespan and included 102 studies. There was substantial heterogeneity among reports, showing the wide variety of options available in terms of accelerometry decisions to assess the 24-hour MovBeh and the lack of *consensus* among researchers.

This review found that the most commonly used accelerometer was the Actigraph GT3X, placed on the wrist in adults and older adults, and on the hip in other age groups. The choice of an appropriate accelerometer and body site depends mainly on the type of MovBeh being measured, as different accelerometers and body sites have different strengths and weaknesses. For example, wrist-worn accelerometers seem to be more accurate in assessing sleep quality metrics, whereas the hip-worn accelerometer may be better for sleep timing and quantity metrics¹⁴⁷. Hip-worn accelerometers have also been shown to be the best option for PA behaviours (mainly MVPA) and thigh-worn accelerometers (e.g. ActivPal) for postural behaviours (e.g. SB)¹⁴⁸, although the devices used in each of these locations may provide different metrics for each of the behaviors^{19,149}.

In terms of measurement properties, and despite the lack of *consensus*³³, both the hip and the wrist-worn accelerometers appear to be suitable to classify PA intensities in toddlers and preschoolers^{150,151}. In adults, some data suggest that wrist-worn accelerometers have better measurement characteristics, particularly for household activities, whereas hip-worn accelerometers are more suitable for locomotion^{152,153}.

Ideally, evidence should focus on understanding the best accelerometer brand/model and body placement that can capture sleep, SB and PA in an integrated way, without having to change body placement. However, there are currently no valid algorithms to do this, and hip and wrist placements provide quantitatively different information about sleep and PA. Therefore, new algorithms and the possible incorporation of additional sensors (e.g. inclinometers, galvanic skin response or heart rate) are needed to accurately

quantify and discriminate sleep duration and PA, as well as the non-wear time of each (non-)movement, which should be further evaluated.

Regarding the number of days of data collection, the most common number of days across all age groups in the studies included in this review was 7 days. MovBeh are inherently variable because people do not exhibit the same behaviours every day, especially children and adolescents; therefore, such a decision depends on the main objective of the study and should reflect a cost-benefit balance between data validity and reliability and participant burden. For example, short data collection periods (e.g. 1-3 days) may be useful if the aim is to measure MovBeh in a specific context, such as a working day or a physical education class. On the other hand, long-term data collection (e.g. at least 7 days) may be useful to accurately measure MovBeh in everyday life^{154,155}, increasing the likelihood of obtaining a sufficient number of valid days and the chance of obtaining both work/week and non-work/weekend days^{30,33,154}.

The most common minimum number of valid days required in the included reports was three weekdays and one weekend day, which is in line with previous recommendations³³. This recommendation emphasises the importance of capturing both work/weekday and non-work/weekend days. This recommendation emphasises the importance of including both work/weekday and non-work/weekend days. This is critical given the typical differences in patterns between these types of days^{156,157}.

The number of minutes required for a valid day varied considerably between the included reports. A recording period of 24 hours is recommended, as this increases both the recording time and the wear time compliance¹⁵⁸; similarly, the criteria for a valid day should be specific to both waking and sleeping hours. In fact, some of the included reports only set a minimum wear time during waking hours.

In this review, the most common non-wear time criteria were ≥ 20 minutes of consecutive zero counts; and based on the standard deviation and range of values for each axis, using a 60-minute window with 15-minute increments.

Given that participants occasionally remove their accelerometers, it is necessary to account for non-wear time, either through self-report or non-wear time algorithms. Indeed, manual input of non-wear time with self-report data is time consuming making the analysis of accelerometry more subjective. On the

other hand, the use of non-wear time algorithms is less time consuming and more objective²⁴. However, there are different algorithms for different age groups and further studies are needed to evaluate them³³. In adults, it seems that the criteria of non-wear time of ≥ 20 minutes or ≥ 60 minutes of consecutive zero counts is the most commonly used and sufficiently accurate to detect non-wear time¹⁵⁹. In older adults, the Choi's algorithm is the most commonly used and the most recommended by previous evidence¹⁶⁰.

In this review, sampling rates ranged from 30 to 100 Hz, although some studies did not report this information. For the assessment of MovBeh, a sampling rate of 30 Hz is considered adequate²⁴, because sampling rates in multiples of 30 produce the most accurate estimates, whereas other sampling rates (i.e. not in multiples of 30) could result in an increase of activity counts¹⁶¹. Therefore, the current recommendation is to use the highest possible sampling rate³³.

This review found that the most commonly used epoch was 15-seconds for toddlers, and 60-seconds epoch for all other age groups; however, there was a range of different epochs were used, possibly because there is no internationally accepted *consensus* for this matter²⁴. In fact, given the spontaneous and intermittent nature of children's MovBeh¹⁶², epochs of 1-15 seconds are recommended^{33,163} to accurately capture the children's MovBeh. In adults, the most commonly used epoch length was 60 seconds, but shorter epochs are recommended as they provide more accurate estimates¹⁶³. For sleep, a 60-second epoch is recommended after the most common sleep algorithms were validated using this epoch length, probably because of the stable movement pattern during sleep^{140,145,164}. The choice of epoch length can drastically alter the final result^{30,165} and shorter epochs can be reintegrated into larger epochs. It is therefore important to develop a consensus on these issues in order to compare studies.

There was considerable variation in the methods used to assess sleep duration. In toddlers and preschoolers, the most commonly used method was manual and visual screening, using logs and accelerometer files. Some reported the use of sleep algorithms. In children and adolescents, the most commonly used sleep algorithm was the Sadeh et al, 1994 sleep algorithm. In adults and older adults, the most commonly used algorithm was the Cole-Kripke

et al, 1992 sleep algorithm. All of these algorithms are consistent with previous findings³⁰. However, it is well known that sleep measurements from different accelerometers are not comparable. Even if the same sleep algorithms are used¹⁶⁶.

Previous studies have reported that wrist-worn accelerometers are better suited for measuring sleep activity when using existing algorithms., when compared with other locations¹⁶⁷⁻¹⁶⁹. However, such advantage can be overcome if sleep behaviour is visually analysed and manually scored, with the support of information from diaries or logs.

The reports included in this review used different cut-points to assess PA and SB. The most commonly used cut-points were Pate et al. 2006 for toddlers and preschoolers, Evenson et al. 2008 for children, Hildebrand et al. 2014 and 2017 and Trost et al. 2011 for adolescents, and Freedson et al. 1998 for adults and older adults. When applying a specific cut point from a calibration study, it is important to follow the same data collection protocol used in the original study (e.g., model, epoch length, placement, age group)^{24,33 170,171}.

In this review, most of the studies with toddlers, pre-schoolers and children did not use logs or diaries; whereas studies with adolescents, adults, and older adults, used diary logs, mainly to detect non-wear time, or sleep time. In fact, the use of diaries or logs is strongly recommended³⁰. However, there is no consensus on the best diary to use for reporting MVPA, and its use in large sample studies may not be feasible.

Accelerometry has several advantages over self-report methods²². However, predetermined methodological decisions, such as data collection procedures and processing criteria, have a significant impact on the interpretation of accelerometer data^{24,30,33}. Despite this, our review confirmed that several studies did not report all the methodological decisions, which consistent with previous work³³. Such reports cannot be accurately compared, making it difficult to interpret how different methodological decisions may have influenced the results. It is important that all methodological decisions regarding accelerometry are reported in future research reports to improve data comparability and reproducibility. However, with all the advances in technology, it is hoped that raw data will be comparable between accelerometer

brands/models and that better data processing methods and study comparability will be possible when data from different studies are pooled¹⁷².

A future consensus on methodological choices in accelerometry could combine the findings of this review and others that focus more on the quality of individual methodological choices^{26-28,33}.

4.1. Strengths and limitations

To the best of our knowledge, this is the first paper to review how researchers manage and describe the methodological procedures of accelerometry in studies measuring 24-hour MovBeh across all age groups, using a scoping review design. This review comprehensively summarised the key methodological decisions regarding accelerometry in terms of data collection procedures and data processing, including a description of the cut-points and algorithms used in all included reports. This review adds another layer to the decisions that need to be made when preparing to collect data on 24-hour MovBeh by helping researchers to define accelerometry protocols. The review also did not impose a date limit on the literature search, resulting in a review with a high number of included papers. As this review included all types of accelerometers (brands and models), the results should be interpreted with the understanding that different accelerometers have specific characteristics. It is also important to note that this review was limited to reporting the most common procedures for methodological decisions for accelerometry, without considering measurement properties and validation/calibration studies. Therefore, this review should not be considered as a list of best practices for the use and processing of accelerometry data. Rather, it should be seen as a compilation of the most commonly used methods in studies that measure all MovBeh over 24-hour periods, which can be used as a useful resource in any future consensus on this topic.

5. Conclusions

This review showed considerable heterogeneity between reports, highlighting the wide range of options available for assessing 24-hour MovBeh using accelerometry and the lack of consensus between researchers. This review also showed that several reports did not disclose all methodological

choices made to assess MovBeh. Therefore, to improve accuracy and allow comparability between studies, consensus on methodological choices is needed, which is challenging given the complexity of the procedures, the number of brands and types of accelerometers available, and the plethora of programming options.

6. Declarations

6.1. Ethics approval and consent to participate

Not applicable

6.2. Consent for publication

Not applicable

6.3. Availability of data and other materials

The data are available upon reasonable request from the authors.

6.4. Competing interests

The authors declare that they have no competing interests.

6.5. Funding

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6.6. Author's contributions

B.R., R.S., R.M., D.P.C. conceived the study. B.R., A.V.-S., S.V. and E.S.-S. collected the data. B.R., R.S and L.L analysed the data. B.R. wrote the first draft of the paper. All authors discussed the results, provided intellectual output, and contributed to writing of the final version of the manuscript.

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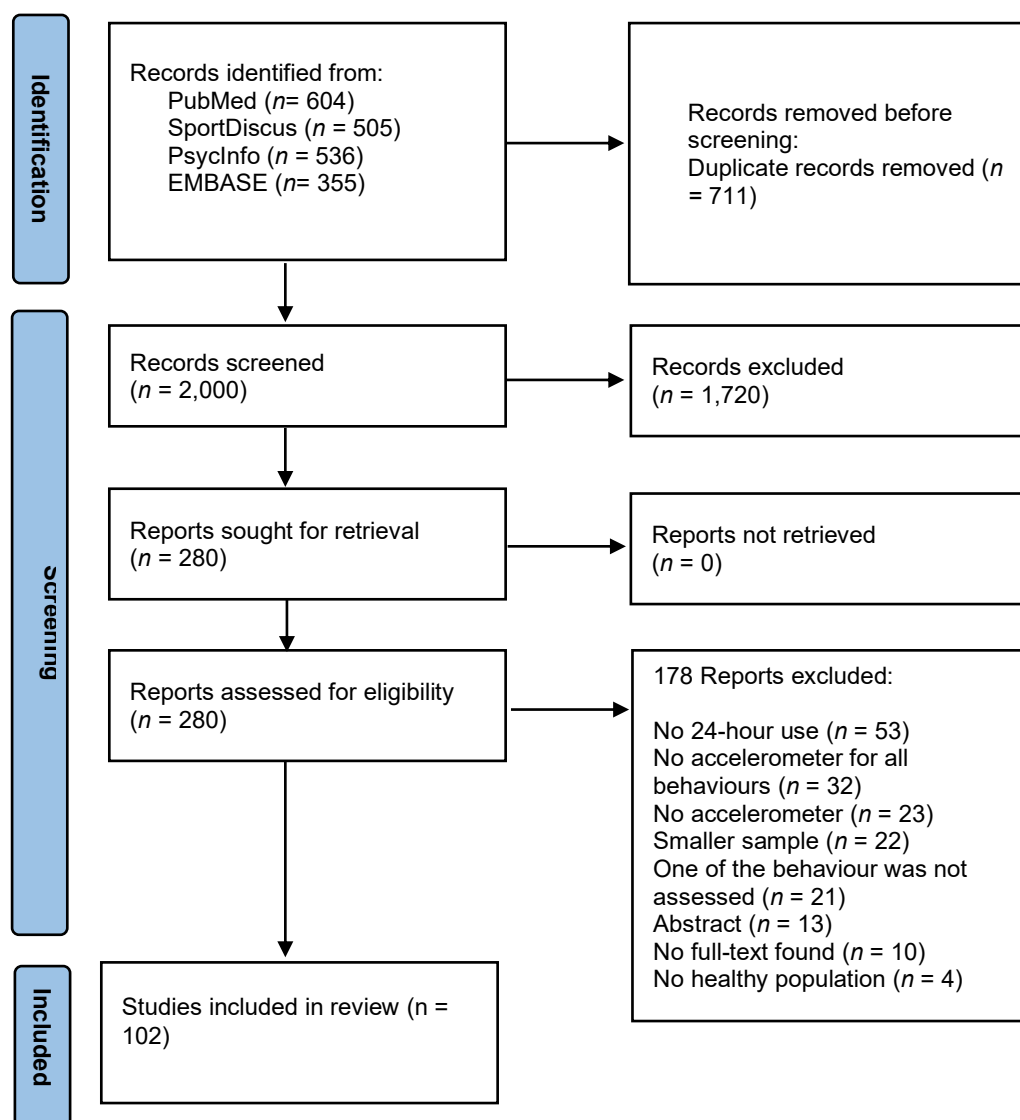
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Figures

Figure 1. Study Selection Process Flowchart



Abbreviations: n= number of studies.

Table 1. Characteristics of reports

Characteristics	Number of Reports
Study Design	
Cross-Sectional	72
Longitudinal	21
RCT	6
Other interventions' designs	3
Sample Size ($n = 140,643$)	
<100	26
100-499	48
500-1000	15
>1000	13
Participants	
Gender (~55.23% girls/women)	
Both genders	94
Boys/Men only	1
Girls/Women only	7
Age	
Toddlers (2-3 years)	3
Preschoolers (3-5 years)	15
Children (5-10 years)	17
Adolescents (10-17 years)	23
Adults and older adults (≥ 18 years)	44
Countries	
USA	32
Australia	10
Spain	9
UK	8
Canada	6
New Zealand	6
Brazil	5
Finland	5
China	4
Denmark	4
Belgium	2
Singapore	2
South Africa	2
Czech Republic	1
Colombia	1
Germany	1
Netherlands	1
Portugal	1
Slovenia	1
Switzerland	1

Table 2. High level summary of findings on accelerometer methods and procedures

	Toddlers and Preschoolers (2-5 years)	Children (5-10 years)	Adolescents (10 to 17 years)	Adults and older adults (≥ 18 years)
Accelerometer model and device placement			- ActiGraph GT3X on hip (5/23), on wrist (1/23).	- ActiGraph GT3X on wrist in (6/44), on hip (2/44), on thigh (2/44).
			- GENEActiv on wrist (4/23).	- GENEActiv on wrist (5/44).
	- Actigraph GT3X on hip (7/18), on wrist (2/18).		- Actical on hip (1/23), on wrist (1/23).	- ActiGraph GT3X on waist for PA and on non-dominant wrist (5/44).
	- Actical on hip (2/18), on ankle (1/18).	- ActiGraph wGT3X on hip (6/17), on wrist (2/17).	- Actiwatch on hip (1/23), on wrist (1/23).	- ActivPAL3 on thigh (2/44), on midline anterior aspect of the upper thigh (2/44).
	- GENEActiv tri-axial on wrist (1/18).	- GENEActiv on wrist (2/17).	- ActiGraph GT9X on wrist (2/23).	- ActiGraph GT9X on wrist (3/44).
	- ActivPAL on anterior thigh midway and Axivity on wrist (1/18).	- FitBit Charge 2 on wrist (2/17).	- ActiGraph GT3X on waist for SB and PA and SleepWatch on wrist for Sleep (1/23).	- SenseWear Pro 3 Armband on arm (3/44).
	- Actiwatch Spectrum on wrist (1/18).	- Actiwatch 4 on wrist (1/17).	- Actiheart on chest (1/23).	- SenseWear Mini Armband on the upper arm (2/44).
	- ActiGraph GT3X on hip and Actiheart on chest (1/18).	- ActiGraph GT9X on wrist (1/17).	- ActiGraph GT9X Link or wGT3X on wrist (1/23).	- Silmee on wrist (1/44).
	- ActiGraph wGT3X on hip and activPAL4 on the thigh (1/18).	- Axivity AX3 on thigh and lower back (1/17).	- ActivPAL4 micro on anterior thigh (1/23).	- Actiwatch-64 on wrist and the Actical on waist (1/44).
	ActiGraph GT9X on hip (1/18).	- ActiGraph GMTI on hip for PA, and on wrist for Sleep (1/17).	- SleepWatch on wrist for sleep and ActiGraph GT3X for SB and PA on waist (1/23).	- Fitbit on wrist (1/44)
		- Actical on hip (1/17).	- ActiGraph wGT3x on hip for SB and PA, and SleepWatch on wrist for sleep (1/23).	- Axivity AX3 on wrist (1/44).
			- ActiGraph wGT3x on hip for SB and PA, and Actiwatch on wrist for sleep (1/23).	- ActiGraph GT3X on hip for SB and PA and ActiGraph GT9X on wrist for sleep (1/44).
				- ActiGraph GT3X for SB and PA and ActiSleep-BT for sleep on wrist (1/44).

				- IDEEA pattern-recognition activity monitor on waist (1/44). - UKK RM42 on hip for SB and PA and on wrist for sleep (1/44). - Actiwatch Spectrum on wrist (1/44). - ActiGraph GT3x on hip for SB and PA and Actiwatch2 on wrist for sleep (1/44). - SenseWear Pro 3 Armband for SB and PA and Two-axis acc for sleep (1/44). - ActiGraph GT1M on hip for SB and PA, and Actiwatch-2 on wrist for sleep (1/44). - Omrom Active Style Pro HJA-350IT on hip for PA and SB and actigraph on wrist for sleep (1/44).
				- 7 days (27/44).
N° of days for data collection	- 7 days (9/18).	- 7 days (11/17).	- 7 days (12/23).	- 14 days (3/44).
	- 5 days (3/18).	- 8 days (3/17).	- 8 days (3/23).	- 10 days (2/44).
	- 3 days (2/18).	- 6 weeks (1/17).	- N.R. (2/23).	- N.R. (2/44).
	- 3-7 days (1/18).	- 6 days (1/17).	- 3 days (2/23).	- 4 days (2/44).
	- 6 days (1/18).	- 6 days (1/17).	- 6 days (1/23).	- 8 days (2/44).
	- 16 days (1/18).	- 3 days (1/17).	- 5 days (1/23).	- 2 days (1/44).
	- 4 days (1/18).		- 4 days (1/23).	- 3 days (1/44).
			- 14 days (1/23).	- 1 days (1/44).

				- 25 days (1/44).
				- 5 days (1/44).
				- 2, 7 and 15 days (1/44)
N° of required valid days	- ≥ 3 wk days and ≥1 wknd day (4/18).		- ≥3 wk days and ≥1 wknd day (6/23).	- ≥3 wk days and ≥1 wknd days (10/44).
	- ≥ 3 days (3/18).	- ≥3 wk days and ≥1 wknd day (7/17).	- ≥ 3 days (5/23).	- N.R. (7/44).
	- N.R. (3/18).	- 3 days (3/17).	- N.R. (4/23).	- ≥ 4 days (8/44).
	- 5 days including 2 weekend days (2/18).	- N.R. (2/17).	- ≥ 4 days (2/23).	- ≥ 3 days (5/44).
	- 1 day (2/18).	- 2 wk days and 1 wknd day (2/17).	- ≥ 5 days including ≥ 1 weekend day (1/23)	- ≥ 1 day (5/44).
	- ≥ 1 day (1/18).	- ≥ 5 nights and ≥4 days, including 1 weekend night and day (1/17).	- ≥ 1 day (1/23).	- ≥3 wk days and 2 wknd days (3/44).
	- 6 days (1/18).	- 6 days (1/17).	- ≥ 6 day (1/23).	- ≥7 wk days and ≥2 wknd day (2/44).
	- 2 wk days and 1 wknd day (1/18).	- 1 day (1/17).	- 5 school days (1/23)	- ≥ 5 day (1/44).
	- 2 days (1/18).		- ≥ 4 days and ≥ 3 nights (1/23).	- ≥ 8 days (1/44)
				- ≥ 6 days including 1 wknd day and ≥ 7 nights (1/44).
Minutes required to be a valid 24-hour period	- 24-hour (3/18).	-10 waking hours/day (3/17).	- ≥10 waking hours/day (8/23).	- ≥ 4 days including 3 nights (1/44).
	- N.R. (3/18).	- 16 h/day (3/17).	- ≥16 h/day (4/23).	- ≥10 waking h/day (17/44).
	- ≥1,000 min/day (2/18).	- 24-hour (2/17).	- ≥10 waking h/day or ≥200 min/day for sleep or ≥1000 min/d for SB (1/23).	- N.R. (5/44).
	- ≥ 8 waking hours (2/18).	- 10 waking h/day for PA and ≥160 min per night and >90% estimated wear time for sleep (1/17).	- ≥ 10 waking h/day; total wear time or	- ≥16 h/day (5/44).
	- ≥ 10 waking h/day (2/18).			- 24-hour/day (3/44).
				- ≥ 600 min/day (2/44).

	- ≥600 min during awake time and an average sleep time ≥200 min (1/18) - 16h/day (1/18). - All sleep h and 8 waking h/day (1/18). - ≥ 7 waking hours for PA and >160 min for sleep (1/18). - ≥ 480 min of wear time and full night (1/18). - ≥ 6 waking h/day (1/18).	- 10 waking hours/day and if the total time was between 20 and 28 hours (1/17). - N.R. (1/17). - ≥20 h/day (1/17). - ≥ 9 waking h/day (1/17). - ≥10 waking h/day with their respective sleeping periods (1/17). - ≥10 waking h/day and with step estimates between 1000 and 30,000 steps (1/17). - ≥10 waking hours and nights were considered valid if the participant provided 20 min of wear time before sleep onset (1/17). - ≥600 min/ day in waking time and an average sleep time ≥ 200 min (1/17).	- wear time plus imputed physical activity ≥ 20 h; ≥ 2 h of sleep (1/23). - ≥ 16 h/day with these hours being roughly equally distributed between the morning (3 am-9 am), noon (9 am-3 pm), afternoon (3 pm-9 pm), and midnight (9 pm-3 am) parts of the day) (1/23). - ≥13 waking h/day (1/23). - ≥ 20 h/day (1/23). - Adhere to sleep intervention and >10 h/day waking hours (1/23). - 24-hour/day (1/23). - 10 waking h for PA and SB, and ≥ 160 minutes for sleep (1/23). - ≥ 16 h/day and < 6 hours or > 12 hours of sleep (1/23). - ≥ 1000 min/day (1/23)	- ≥8 waking h/day (2/44). - ≥ 1296 minutes (1/44). - ≥4 h of work and leisure and ≥4 of sleep (1/44). - ≥ 3 h/day (1/44). - ≥23 h/day (1/44). - ≥21 h/day (1/44). - ≥23 h/day (1/44). - ≥10 waking h/day and with the sleep period detected (1/44). - >1200 min/day (1/44). - ≥10 and ≥8 waking/h day on wk days and wknd days, respectively (1/44). - ≥18.5/h day (1/44).
Criteria for non-wear time	- ≥ 20 min of consecutive zeros (9/18; 2 studies only on waking hours). - N.R. (2/18). - Choi algorithm (2/18). - No non-wear time (1/18). - Through manually and visually Screened (1/18). - Based on the SD and value range of each axis, using a 60-min	-N.R. (3/17). - ≥ 20 min of consecutive zeros (3/17; 1 study only on waking hours). - ≥ 10 min of consecutive zeros (2/17: 1 study only on waking hours). - Based on the SD and value range of each axis, using a 60-min window with 15-min increments (2/17). - Troiano (2007) algorithm provided	- N.R. (4/23). - Based on the SD and value range of each axis, using a 60-min window with 15-min increments (4/23). - ≥ 20 min of consecutive zeros (3/23). - Defined by diary (2/23). - ≥60 consecutive minutes of zero counts, with allowance of 2 min of counts between 0 and 100 (2/23).	- N.R. (15/44). - Based on the SD and value range of each axis, using a 60-min window with 15-min increments (6/44). - ≥ 60 min of consecutive zeros (6/44; 2 study this was supported by diary and visual inspection). - Temperature outputs and visual inspection (3/44). - Choi's algorithm 2007 and 2011 (2/44).

	window with 15-min increments (1/18). - If no movement was recorded at night, it was assumed that the acc was removed prior to bedtime. 60 consecutive min of nonmovement was defined as an invalid hour. (1/18). - Off-wrist detection with a button to mark events in the record (1/18).	by ActiLife (1/17). - Tudor-Locke et al., 2015 filter (1/17). - ≥ 15 min of consecutive zeros (1/17). - Defined by diary (1/17). - R-package GGIR detects non-wear time (1/17). - Using the in-built temperature sensor (1/17).	- ≥ 90 min of consecutive zeros (2/44). - Defined by diary (2/44). - When heart rate counts were zero (1/44). - No non-wear time (1/44). - ≥ 60 consecutive minutes of zero counts, with allowance of 2 min of counts between 0 and 100 (1/44). - Choi et al. algorithm to the hip accelerometer data to identify non-wear time, after sleep periods be marked as wear time (1/44). - Periods of 60 minutes of less than 25 counts per minute (1/44). > 120 min in quiescent time (1/44). - 2h or any bout ≥ 5 h without detectable movement (1/44). - ≥ 20 min of consecutive zeros (1/44).	
Epochs Length and data reduction (epochs integration)	- Sampled at 30 Hz and reintegrated into 15-s epochs (5/18). - 15-s epochs (5/18). - 1-min epochs (3/18). - Sampled at 30 Hz and reintegrated into 5-s epochs	- 1-min epochs (5/17). - Sampled at 30 Hz and converted in 1-s (1/17) and 1-min (2/17). - 15-s epochs. (2/17). - Sampled at 80 Hz, downloaded in 1-s epochs, and reintegrated to 15- and 60-s epochs (1/17).	- N.R. (3/23). - Sampled at 30 Hz and reintegrated into 15-s (1/23), 5-s (1/23), and 1-min epochs (1/23). - Sampled at 100 Hz and reintegrated into 5-s (2/23) and 1-s epochs (1/23).	- 1-min epochs (10/44). - N.R. (9/44). - Sampled at 100 Hz and reintegrated into 1-s (2/44), 6-s (1/44), and 1-min epochs (2/44). - Sampled at 30 Hz. reintegrated into 5-s (1/44), and 1-min epochs

(2/18).		- 1-min epochs. (2/23).	(3/44).
- Sampled at 87.5 Hz and reintegrated into 1-s epochs (1/18).	- 80 Hz (1/17).	- Sampled at 75 Hz and reintegrated into 5-s epochs (1/23).	- 20 Hz (3/44).
- 80 Hz (1/18).	- N.R. (1/17).	- Sampled at 50 Hz and reintegrated into 1-min epochs (1/23).	- Sampled at 50 Hz, reintegrated into 1-min epochs (2/44).
- Sampled at 80 Hz and reintegrated into 15-s epochs for PA and 1-min epochs for sleep (1/18).	- 1-s epochs for PA and 1-min epochs for sleep (1/17).	- Sampled at 30 Hz and the measured accelerations stored at 1 Hz after conversion into proprietary "activity count units" summed over a 1 s epochs. For PA: 1-min epochs was used (1/23).	- 50 Hz (1/44).
- 1-s epochs (1/18)	- Sampled at 87.5 Hz and converted into 5-s by R-package GGIR (1/17).	- Sampled at 30 Hz and reintegrated into 15-s epochs and collapsed into 1-min-epochs (1/23).	- 40 Hz and reintegrated into 1-min epochs (1/44).
	- 87.5 Hz (1/17).	- Sampled at 100 Hz and converted to 1 omnidirectional measure of acceleration (ENMO), that was reintegrated into 5-s epochs (1/23).	- 100 Hz (1/44).
	- Sampled at 100 Hz and reintegrated in 5-s epochs (1/17).	- 30-s epochs (1/23).	- Sampled at 30 Hz and reintegrated into 1-min epochs for sleep and into 15-s epochs for PA (1/44).
		- 5-s epochs (1/23).	- 80 Hz (1/44).
		- 15-s epochs (1/23).	- 32 Hz (1/44).
		- 20 Hz (1/23).	- 40 Hz (1/44).
		-30-s 1-s epochs for PA; 60-s 1-s epochs for sleep (1/23).	- 30-s epochs (1/44).
		- Sampled at 80 Hz and reintegrated into 1-s epochs (1/23).	- 5-s epochs (1/44).
		- 1-min epochs (1/23).	- 1-s epochs (1/44).
			- Sampled at 100 Hz and processed as 10-s epoch. Sleep was analyzed by 1-min epoch (1/44)

Movement Behavior outcome and Reporting formats	- Sleep, SB, LPA, and MPA (h or min/day) (4/18).	- Sleep, SB, LPA, MVPA (h or min/day) (6/17).	- Sleep, SB, LPA, MVPA (min/day) (13/23).	- Sleep, SB, LPA, MVPA (min/day) (20/44).
	- Sleep, SB, LPA and MVPA (h or min /day) (4/18).	- Sleep, SB, LPA, MPA and VPA (h or min/day) (3/17).	- Sleep, SB, LPA, MPA, VPA, MVPA (h or min/day) (4/23).	- Sleep, SB, and MVPA (h or min/day) (4/44).
	- Sleep, SB, LPA, MPA, VPA and TPA (h or min/day) (2/18).	- Sleep, SB and MVPA (h or min/day) (3/17).	- Sleep, SB, and MVPA (h or min/day) (2/23).	- Sleep, SB, LPA, MPA and VPA (h or min/day) (2/44).
	- Sleep, SB, TPA (% of 24-hour) (2/18).	- Sleep, SB, LPA, MVPA (% of 24-hour period) (1/17).	- Sleep, SB, LPA, MVPA (min/day and % of 24-hour) (1/23).	- Sleep, SB, LPA, MPA, VPA and MVPA (h or min/day) (3/44).
	- Sleep, SB, LPA, MVPA, TPA (h or min/day) (2/18).	- Sleep, SB, LPA and MVPA (min day); TPA (cpm); Steps (min ⁻¹) (1/17).	- Sleep, SB and LPA (% of day), MVPA (min/day) (1/23).	- N.R. (2/44).
	- Sleep, SB, MPA and VPA (h or min/day) (1/18).	- Sleep, SB, LPA, MVPA (h or min day); TPA (cpm) (1/17).	- Sleep, SB, LPA, MPA and VPA (h or min/day) (1/23).	- Sleep, SB, LPA and MVPA (min day and % of 24-hour) (2/44).
	- Sleep, SB, LPA, MPA, VPA (h or min/day) (1/18).	- Sleep, SB, LPA, MPA, VPA, MVPA (min/day) (1/17).	- Sleep, SB and VPA (h or min/day) (1/23).	- Sleep, SB, LPA, MVPA (proportion of the 24-h day) (2/44).
	- Sleep, SB, MVPA (h or min/day) (1/18).	- Sleep, SB, LPA, MPA, VPA, MVPA (min/day) (1/17).		- Sleep (h/day) SB and MVPA (time %), and number of steps per day (1/44).
	- Sleep, SB, Screen time, LPA, MPA and VPA (h or min/day) (1/18).	- Sleep, SB, LPA, MVPA and TPA (min/day) (1/17).		- Sleep, SB, LPA, MVPA, TPA (h or min/day) (1/44).
				- Sleep and SB (h/day); PA (steps/day) (1/44).
				- Sleep, SB, standing time, LPA, MVPA (% of 24-hour) (1/44).
				- Sleep, SB, LPA, MPA, VPA, and VVPA (h or min/day) (1/44).
				- Sleep, SB, and standing (h/day), Stepping (steps/min) (1/44).
				- Sleep, SB, LPA, MPA, VPA, VVPA (% of time) (1/44).

				- Sleep, SB, standing, LPA, MPA, VPA (h or min/day) (1/44). - “Minutes asleep” for each sleep episode and “Total minutes asleep” within a day. - Daily total step counts, “Very active minutes”, “Fairly active minutes”, and “Lightly active minutes” (1/44).
Sleep measuring procedure	- Manually and visually screened, considering log and accelerometer files (4/18). - Sleep algorithm (Hees et al. 2015) (2/18). - Sleep algorithm (Sadeh et al., 1994) (2/18). - Sleep algorithm. (Hjorth et al. 2012) (2/18). - number of min asleep between sleep onset and sleep offset.; Daytime napping: 30 successive epochs of sleep that occurred between 09:00 and 17:00 (1/18). - Sleep algorithm Tudor-Locke (2014) (1/18). - CREA algorithm (1/18). - Sleep onset, as the start of the first 15 continuous minutes of sleep preceded by 5 min of awake, to offset, as the last of 15 continuous minutes of sleep followed by 5 min of awake. Matlab script defines naps during daytime wake periods (9 a.m.–5 p.m.) as at least 30 min of	- Sleep algorithm (Sadeh et al., 1994) (4/17). - Sleep algorithm (Hees et al., 2015) (3/17). - Sleep algorithm (Tudor-Locke et al. 2014) (2/17). - Sleep algorithm (Meredith-Jones et al., 2016) (2/17). - Actiwatch Activity & Sleep Analysis 5 algorithm (1/17). - Sleep algorithm (Hees et al., 2018) (1/17). - Sleep period lasting >240 min with sleep onset between 7 PM and 6 AM and offset between 5 AM and 1 PM (1/17). - Sleep algorithm (Barreira et al., 2015) (1/17). - Sleep algorithm (Cole–Kripke et al., 1992) (1/17) - >160 consecutive minutes classified as “asleep” between 7:00 pm and 11:58 am (1/17).	- Sleep algorithm (Sadeh et al., 1994) (5/23). - Manually and visually screened, considering log and accelerometer files (3/23). - Sleep algorithm (Hees et al., 2018) (4/23). - Sleep algorithm (Hees et al., 2015) (2/23) - The accumulated time spent in ≤1.5 METs between a designated sleep onset and termination period (1/23). - Summing activPAL4 output called “primary lying time” and self-reported napping time (1/23). - Sleep algorithm (GENEActiv Post-Processing PC Software) with support of body temperature and luminosity sensors (1/23). - Sleep algorithm (Barreira et al., 2015) (1/23). - Pressing an event marker button (1/23).	- Sleep Algorithm (Cole–Kripke et al., 1992) (8/44). - Sleep Algorithm (Hees et al., 2015) (6/44). - Manually and visually screened, considering log and accelerometer files (5/44). - Sleep Algorithm (Hees et al., 2018) (3/44). - Sleep Algorithm (Oakley 1997) (3/44). - SenseWear pattern recognition algorithms (3/44). - Sleep Algorithm (Shin et al., 2015) (2/44). - Sleep Algorithm (Winkler et al. 2016) (2/44) - Number of minutes asleep between sleep onset and sleep offset: with no movement for more than 20 min; was measured between 6:00 pm and 5:59 am and corrected visually (1/44). - Pressing an event marker button

continuous sleep, preceded by 5 min of awake) (1/18).	- The point when the cpm data changed to consecutive zeros lasting about 8-10 hours and cross-checked with the participants' wear log for "off" times (1/17).	- CREA algorithm (1/23).	(1/44).
- Combination of sleep diaries and button-marked events (1/18).		- N.R. (1/23).	- N.R. (1/44).
- Identified by abrupt increases in activity and heart rate and supported by diaries (1/18).			- Total nighttime sleep derived from minute-by-minute sleep epochs (1/44).
- Sadeh and Tudor-Locke algorithms (1/18)			- Defined as having non-nap sleep duration >3 hr. Nap is a sleep episode with a start time between 8 am to 5 pm. Sleep duration was computed by subtracting total nap minutes from "total minutes asleep." (1/44)
- At least 10 consecutive minutes with a vector magnitude > 0 (1/18)			- Machine learning model Doherty et al., 2018 (1/44).
			- Total amount of time spent in bed minus sleep onset latency (1/44).
			- Sleep Algorithm (Cabanas-Sanchez et al., 2018) (1/44).
			- The last registered non-sedentary epochs of the day, which was followed by a long uninterrupted sedentary period (> 2 h), was identified as sleep (1/44).
			- Sleep Algorithm (Sadeh et al. 1994) (1/44).
			- Sleep Algorithm (Berger et al., 2008) (1/44).
			- Prolonged periods (>2 hours) of continuous inactivity during sleeping hours (extracted from the activPAL raw output) (1/44)

PA and SB cut points	- Pate et al., 2006 (4/18). - Hager et al., 2016 (1/18) - Trost et al., 2012 (1/18) - SB, LPA, MPA and VPA TPA (total recorded counts/wear time) (1/18) - SB (0–467 cp15s), LPA (468–2,207 cp15s); MPA (2,208–3,991 cp15s) and VPA ($\geq 3,992$ cp15s); No authors (1/18) - Hildebrand et al., 2014 and 2017 (1/18) - SB (If more than 45 s of the 60 s epochs were spent sitting or lying, these epochs were classified as SB); Activity (Yes if there was no SB and no Sleep) (1/18). - Janssen et al., 2003 and Pate et al., 2010 (1/18). - Adolph et al., 2012 and Trost et al., 2010 (1/18). - Ekblom et al., 2012 (1/18). - Evenson et al., 2008 (1/18). - Butte et al., 2014 (1/18). - Freedson et al. 1998 (1/18). - Hjorth et al. 2012 (1/18).	- Evenson et al., 2008 (7/17; one study did not define the cut-point). - SB (0%-19.9% HRR), LPA (20%-49.9% HRR) and MVPA ($\geq 50\%$ HRR) (2/17). - SB (≤ 1.5 METs or < 332 cpm), LPA (1.5 to 3 METs or 332 to 1004 cpm), MPA (3 to 6 METs or 1004 to 2336 cpm) and VPA (> 6 METs or > 2336 cpm); no author or N.R. (1/17) - Hildebrand et al., 2014 and 2017 (1/17). - Chandler et al., 2016, Gavarry et al., 1998 (1/17) - Hildebrand et al., 2014 (1/17) - Trost et al., 2011 (1/17) - Not clear (1/17) - Puyau et al. 2004 (1/17)	- Hildebrand et al 2014 and 2017 (3/23). - Trost et al., 2011 (2/23). - Romanzini et al. 2014 (2/23). - Hildebrand et al., 2014 (1/23) - Philips et al., 2013 (1/23). - Sasaki et al., 2011 (1/23). - Kozey-Keadle et al., 2011), and Freedson et al., 1998 (1/23). - Hurter et al., 2018 and Hildebrand et al., 2014 (1/23). - SB (≤ 1.5 METs), LPA (1.5 to 4 METs), MPA (1.5 to 4 METs) and VPA (> 7 METs); no authors or N.R. (1/23). - Chandler et al., 2016 (1/23). - Payau et al., 2002 (1/23). - SB: summing activPAL4 output “sitting time” and “secondary lying time”, while deducting self-reported napping time; LPA: residual time to wear time (LPA = 24 h—Sleep—SB—MVPA—non-wear time); MVPA (100 steps per minute) (1/23). - Evenson et al., 2008 (1/23) - Puyau et al. 2004 (1/23)	- Freedson et al., 1998 (6/44). - Hildebrand et al., 2014 (4/44) - SB (< 1.5 METs), LPA (1.5–3 METs); MPA (3–6 METs); VPA (6–8.9 METs) Very VPA (9 METs) (3/44). - N.R. (1/44). - Esliger et al., 2011 (2/44). - Shin et al., 2015 (2/44). - Rowlands et al. 2018 (2/44). - Sasaki et al. 2011 and Aguilar-Farias et al. 2014 (2/44). - White et al., 2016 (1/44) - SB (≤ 1.5 METs), LPA (1.5–3.0 METs), MVPA (≥ 3 METs); algorithms developed by the Silmee™ (1/44). - Hamer et al., 2020 (1/44) - SB: subtracted the habitual sleep time from the 24-hour sedentary time of each participant to calculate the amount of habitual sedentary time when he or she was awake; LPA, MPA and VPA: Heil 2006 (1/44) - Hildebrand et al., 2017 (1/44) - SB (≤ 1.5 METs), PA (Average

- Trost et al., 2012 and Butte et al., 2014 (1/18)	- Trost et al., 2012 (1/23). - Ekblom et al. 2012 (1/23). - N.R. (1/23).	daily steps) (1/44). - Evenson et al., 2015 (1/44). - SB (subtracting the active and light activity minutes from the total valid wear time); Active minutes: sum of the "very active" and "fairly active" minutes) (1/44). - Machine learning model Doherty et al., 2018 (1/44). - Behaviors were detected by using proprietary (SenseWear) pattern recognition algorithms that are refined over time (1/44). - Lying, reclining, passive sitting, active sitting, standing, walking, and other activities; Cut points were not clear. Walking was divided into two categories according to the 2.5-mph cutpoint, which identifies light (<2.5 mph) and moderate-to-vigorous (≥2.5 mph) intensities (1/44). - Copeland et al., 2009 and Matthews et al., 2008 (1/44). - SB and standing time (calculated using the postural function of the monitor, through the proprietary software (ActiPal). LPA (24-hour - (SB + standing time + MVPA); MVPA: Powell et al., 2017 (1/44). - Sitting and/or lying and standing and walking slow (SB and LPA; <100 steps per min) and running, cycling and stair climbing (MVPA; >100 steps per min) (1/44).

		- Troiano et al. 2008 (1/44). - Landry et al. 2015 (1/44). - Winkler et al. 2016 algorithm (1/44). - Lee et al. 2019 (1/44). - Reece et al., 2015 (1/44). - SB (Sleep duration was subtracted from total sedentary time to obtain waking hours" sedentary time); Stepping and standing (N.R.) (1/44). - Vähä-Ypyä et al., 2015 (1/44). - Crouter et al., 2015 (1/44).	
Procedures for handling non-compliant participants	- Non-compliant participants were excluded from the analyses. (17/18). - The invalid data were imputed using the mean value of valid data at same time points on other days (1/18).	- Non-compliant participants were excluded from the analyses. (13/17).	- Non-compliant participants were excluded from the analyses. (17/23).
		- For each 15-min period detected as non-wear time over the valid wearing days, the invalid data were imputed using the mean value of valid data at same time points on other days (2/17). - Non-wear time was reallocated to other day-time components (sedentary, LPA, and MVPA) by multiplying the proportions of day-time wear by total daytime in minutes (1/17). - If epochs of low activity existed outside of the scoring interval or if non-wear time occurred during the interval, a consensus was reached	- Non-wear data were imputed by the average at similar time points on other days of the week (2/23) - For each 15 min period detected as non-wear time over the valid wearing days, missing data were imputed using the mean values calculated from valid data at the same time points on other days. - Any days with ≤ 200 min of sleep duration or ≤ 1000 min of ST was considered invalid and were excluded from the analysis (1/23). - If the device was removed for "sport", the
		- Non-compliant participants were excluded from the analyses. (40/44). - Non-wear data or Abnormal high accelerations were imputed by the average at similar time points on other days of the week (2/44). - Intent-to-treat using chained equations (R Studio) (1/44). - Non-wear time reallocated to other wake components proportionally based on the time they contributed to the total day (1/44).	

		by the research team (1/17).	corresponding period of non-wear was imputed with 50% MVPA, 30% LPA and 20% sedentary time (1/23) - Activities that were performed during non-wear time, were also recorded and then manually imputed (manually imputed data accounted for 0.5% of total wear time) (1/23). - If non-wear time existed, the data on lecture/leisure movement behaviors were proportionally rescaled to fit a specific time period (1/23).
Log or diary	- No use (7/18).		- Sleep diary/log (17/44).
	- Sleep and non-wear time diary/log (3/18).	- No use (9/17).	- No use (7/44).
	- Parents reported their child's movement behaviors on questionnaires (3/18).	- Sleep and non-wear time diary/log (3/17).	- Sleep and non-wear time diary (7/44)
	- Sleep diary (3/18)	- Sleep diary/log (3/17)	- Work times, sleep and non-wear diary (4/44)
	- EMA for sleep (1/18).	- Non-wear time diary (1/17)	- Movement behavior diary/log (4/44).
	- Movement behaviors and non-wear time diary (1/18)	- N.R. (1/17)	- Non-wear time diary (2/44).
			- N.R. (2/44)
			- Sleep questionnaire (1/44)

Legend: SD: Standard Deviation; h: hours; min: minutes; s: seconds; SB: sedentary behavior; PA: physical activity; LPA: light physical activity; MPA: moderate physical activity; VPA: vigorous; MVPA: moderate to vigorous physical activity; TPA: total physical activity; cpm: counts per minute; N.R.: not reported; Hz: Hertz; cp15s: counts per 15 seconds; METs: Metabolic equivalents; ENMO: Euclidean Norm Minus One; HRR: Heart Rate Reserve.

Table 3. Sleep algorithms by accelerometer model

Authors	Age group	Brief explanation	Accelerometer/body placement
Non-wear time			
Choi et al., 2012	Toddlers and Preschoolers (1) Adolescents (1) Adults and older adults (2)	At least 90-minutes of consecutive zero counts in the vertical axis, with an allowance of up to 2 minutes of interruptions if no activity counts are detected within 30-minutes of upstream and downstream from that interval.	ActiGraph GT3X on hip (1), on hip and wrist (2) ActiGraph GT9X on wrist (1)
Troiano 2007	Children (1)	Intervals of at least 60 consecutive minutes with zero activity counts, allowing 1 to 2 minutes of counts between 0 and 100.	ActiGraph GT3X on hip (1)
Movement and Posture			
VANE algorithm (ActivPAL-Software)	Toddlers and Preschoolers (1) A	The algorithm uses the thigh location of the activPAL to identify sitting, standing and stepping events. Upright and not-upright separation is identified by using the inclination function of the accelerometer. The dynamic accelerations during stepping caused by the movement of the thigh and foot strike are used to detect stepping events.	ActivPAL on thigh (1)
BodyMedia algorithm	Adults and older adults (1)	Activity parameters are estimated using proprietary algorithms based on combined information of body movement (captured by a triaxial accelerometer) and physiological responses (assessed with heat flux, galvanic skin response, skin temperature, and near-body temperature sensors).	SenseWear Mini Armband on arm (1)
Sleep			
Sadeh et al., 1994	Toddlers and Preschoolers (4) Children (4) Adolescents (5) Adults and older adults (1)	Classifies sleep into three categories: Sleep onset, sleep efficiency and wake after sleep onset. These categories are used to calculate total sleep time. The algorithm considers parameters as the magnitude and duration of body movements and the Circadian rhythm, to determine the categories. The time when the person go to bed is defined as the minute with < 10 cpm after four consecutive minutes of ≥10 cpm in the evening and the time, when the person is out of bed is defined as the min before four consecutive minutes of ≥10 cpm in the morning.	ActiGraph GT3X on wrist (5), on hip (4) SleepWatch on wrist (2) Actical on ankle (1), on waist (1) ActiGraph GT9X on wrist (1)
Hees et al. 2015	Toddlers and Preschoolers (2) Children (3) Adolescents (2) Adults and older adults (6)	Periods of time within the bedtime and waking times reported in the daily logs during which there was no change larger than 5° in the arm angle over at least 5 min. The algorithm classifies each 5 s epoch as either sleep or wake. Categorizes sleep into three categories: light sleep, deep sleep and REM sleep. These three categories are used to calculate the total duration of sleep in each state and the proportion of time spent in each of these stages. The algorithm considers parameters as the magnitude of body movements, to determine the depth of sleep.	GENEActiv on wrist (7) ActiGraph GT3X on wrist (4) ActiGraph GT9X on wrist (3) ActiSleep on wrist (1)
Cole–Kripke et al., 1992	Children (1) Adults and older adults (9)	Categorizes each minute of the identified sleep period as either “awake” or “asleep”. Assisted by log. Classifies sleep into two categories: Effective sleep (without considering any periods of wakefulness) and wake after sleep onset. These categories are used to calculate total sleep time, which is the sum of actual sleep and awakening after sleep onset. The algorithm takes into account parameters as movement amplitude, mean activity and periodic limb movements.	Actiwatch 4 on wrist (1) Actigraph GT3X on wrist (6), on hip (1) Actigraph GT9X on wrist (2)
Hees et al.,	Children (1)	Looking at the distribution of change in Z-angle, which was applied to detect sustained	Actigraph GT3X on wrist (2)

2018	Adolescents (4) Adults and older adults (3)	inactivity bouts where the z-angle did not change by more than 5 degrees for at least 5 min. The algorithm classifies each 5 s epoch as either sleep or wake. Categorizes sleep into three categories: light sleep, deep sleep and REM sleep. These three categories are used to calculate the total duration of sleep in each state and the proportion of time spent in each of these stages. The algorithm considers parameters as the magnitude of body movements, to determine the depth of sleep.	GENEActiv on wrist (3) Actigraph GT9X on wrist (2) Actiwatch on wrist (1)
Tudor-Locke (2014)	Toddlers and Preschoolers (2) Children (2)	Automated algorithm that requires non accelerometer bed- and wake-time inputs, relative to a criterion expert visual analysis of minute-by-minute waist-worn accelerometer data. The sleep onset is defined by the inclinometer and also by 2 conditions: the first minute with a recorded vector magnitude of <1000, followed by at least 4 min of a vector magnitude of <500 and <10 steps per min; and at least 90 min needed to elapse between bedtime and wake time. The sleep offset is defined by the inclinometer output and then defined as the first minute with either of the 2 following data patterns: a high amount of activity (>1500 vector magnitude), accompanied by >20 steps per min and at least 4 min with a vector magnitude of >0; or at least 10 consecutive minutes with a vector magnitude of >0.	Actigraph GT3X on wrist (1), on hip (2) Axivity AX3 on thigh and lower back (1)
Sensewear algorithm; Shin et al., 2015	Adults and older adults (5)	Detects sleep duration through the characteristic combination of orientation, motion, temperature, and skin conductivity with each sleep stage.	SenseWear armband on the upper arm (5)
Hjorth et al. 2012	Toddlers and Preschoolers (2)	Nocturnal activity (counts), total sleep time (min), and sleep efficiency (%) are the three measures of sleep. Nocturnal activity is all counts within the reported time span between lights off and lights on, total sleep time is the minutes scored as sleep within the reported time span between lights off and lights on, and sleep efficiency is the percent of sleeping time within the reported time span between lights off and lights on. Could be used to obtain a proxy measure of total sleep time for ranking purposes in epidemiological studies.	Actigraph GT3X on hip (2)
Meredith-Jones et al., 2016	Children (2)	An automated script developed in MATLAB that removes the appropriate sleep period for each day for each child individually, to avoid sleep being misclassified as sedentary time.	Actigraph GT3X on hip (2)
Barreira et al., 2015.	Children (1) Adolescents (1)	Is a refinement of the Tudor-Locke algorithm. Sleep onset was defined as the first of five consecutive minutes scored as sleep from the Sadeh + inclinometer algorithm (SIA). Sleep offset was defined as the first of 10 consecutive minutes of SIA-scored wake minutes. In addition, sleep period time (SPT) was only identified if >160 min elapsed between sleep onset and sleep offset. To only focus on nocturnal sleep, sleep onset could only occur between 7:00 p.m. and 5:59 a.m. Second, the definition of sleep offset was refined and identified as the first of 10 or 20 consecutive SIA-scored wake minutes, depending on the time of day (10 min—5:00 a.m. to 11:58 a.m.; 20 min—9:40 p.m. to 4:59 a.m.). Refinements allowed identification of extended episodes of wakefulness separating the SPT into distinct sleep episodes with multiple sleep onsets and offsets.	Actigraph GT3X on hip (2)
Oakley 1997	Adults and older adults (3)	Sleep duration is estimated by scoring the data during 30-s epochs as “sleep” or “wake”, after manually editing the sleep period using sleep diary data and event and light markers. Each epoch of data from the Actiwatch is assessed as sleep or wake, based on whether or not the activity score exceeds 40 counts. The average sleep duration is computed from nighttime	Actiwatch on wrist (3)

		sleep onset (sleep start time; 5 immobile minutes) and morning waking (sleep end time; 0 immobile minutes), averaging sleep duration.	
CREA algorithm (ActivPAL algorithm)	Toddlers and Preschoolers (1) Adolescents (1)	Identifies non-upright events lasting at least one hour and then expanding each event to adjacent non-upright events lasting at least one hour (thus allowing for bathroom breaks and other sleep interruptions), resulting in a container of predominantly non-upright events. The longest container is flagged as the single 'Primary Lying Time' variable, which is considered a proxy for time in bed. The beginning of 'Primary Lying Time' container is identified by the algorithm as 'Time in Bed Start Time', which is considered "bedtime", and the end of the container is identified as 'Time in Bed End Time', which is considered "wake time."	ActivPAL on thigh (2)
Actiwatch Activity & Sleep Analysis	Children (1)	Identifies each epoch as sleep or waking using a mathematical model. Sleep onset is manually set as the first epoch scored as immobile that was sustained for ten minutes or longer. Sleep end is set as the last epoch scored as immobile that was sustained for ten minutes or longer.	Actiwatch 4 on wrist (1)
GENEActiv Post-Processing PC Software	Adolescents (1)	No information found.	GENEActiv on wrist (1)
Cabanas-Sanchez et al., 2018	Adults and older adults (1)	Sedentary bouts ≥ 300 min are classed as sleep bouts. If no sedentary bouts ≥ 300 min is found, the algorithm consider as sleep the longest sedentary bout per day that lasted ≥ 120 min. The algorithms then iteratively examine surrounding bouts, determining if they were likely to belong to sleep period time. Surrounding bouts are considered as any bout within a 15min moving window before or after a sleep bout. Bedtime is established as the first register of the first sleep bout, wake time is considered as the first register after the last sleep bout, and the sleep period time is considered as the time (h) between bedtime and wake time.	IDEEA pattern-recognition activity monitor on hip (1)
Winkler et al. 2016	Adults and older adults (2)	The longest bout in a 24-h day that is ≥ 2 h or any bout ≥ 5 h without detectable movement was classified as non-wear/sleep. The algorithm also examines surrounding bouts and determines whether they are more likely additional sleep/non-wear or waking wear. Bouts are 'surrounding' if any portion is within a 15min window before or after a sleep/ non-wear bout. All bouts in the sleep window were classed as sleep/non-wear when the window contains any of these: a sitting/lying or standing bout that is long (≥ 2 h), or moderately long (≥ 30 min) with very few (≤ 20) steps in between. This repeats until no more sleep/non-wear is found.	ActivPAL on thigh (2)

Table 4. Cut points by accelerometer model and age group

Cut point (n° times)	Cut point/ Accelerometer and Body place	Age group			
		Toddlers/ Preschoolers	Children	Adolescents	Adults/Older adults
Evenson et al., 2008 (8)	SB (0–47 cpm), LPA (48–2031 cpm), MPA (2032–2875 cpm), VPA (≥ 2876) / Actical on waist (#1)	1			
	Vertical (uniaxial) axis cut-points: SB (0-25 cp15s), LPA (26–573 cp15s), MPA (574–1002 cp15s) and VPA (≥ 1003 cp15s) / Actigraph GT3X on hip (#4)		3	1	
	SB (0-100 cpm), LPA (101–2295 cpm), MPA (2296–4011 cpm) and VPA (≥ 4012 cpm) / Actigraph GT3X on hip (#1); ActiGraph GMTI on hip (#1)		2		
	N.R. / Axivity AX3 on thigh and lower back (#1)		1		
Hildebrand et al., 2014 and 2017 (7)	SB (ENMO ≤ 35 mg), LPA (ENMO 35–200 mg), MPA (ENMO 200 to 707 mg) and VPA (ENMO ≥ 707 mg); ENMO values were averaged over 5 s epochs / ActiGraph GT3X on wrist (#4)	1	1	2	
	SB (ENMOZ 0–56.3 mg), LPA (ENMOZ 56.3–191.6 mg), MPA (ENMOZ 191.6–695.8 mg) and VPA (ENMOZ >695.8 mg) / GENEActiv on wrist (#2)		2		
	SB (0–40 mg (minus sleep)); LPA (41–199 mg); MVPA (≥ 200 mg) / GENEActiv on wrist (#1)			1	
Freedson et al., 1998 (7)	N.R. / ActiGraph GT3X on hip (#1)	1			
	SB (0-99 cpm), LPA (100–1951 cpm), MPA (1952–5724 cpm), VPA (5725–9498 cpm), and VVPA (>9499 cpm) / Actigraph GT9X on wrist (#1); ActiGraph GT3X on hip (#3), ActiGraph GT1M on hip (#1); SensewearPro on arm (#1)				6

Hildebrand et al., 2014 (6)	SB/LPA (2 METs) and MVPA (4 METs) / ActiGraph GT9X on wrist (#1)		1		
	SB (ENMO < 52 mg); LPA (ENMO 52–191 mg); MVPA (ENMO ≥ 192 mg); ENMO values were averaged over 5 s epochs / GENEActiv on wrist (#1); ActiGraph GT3X on wrist (#1); ActiGraph GT9X on wrist (#1)			1	2
	SB (<30 mg), LPA (30 < 99 mg), MPA (100 < 399 mg), and VPA (>400 mg) / ActiGraph GT3X on wrist (#2)				2
Pate et al., 2006 (4)	SB (≤199 cp15s), LPA (≥200 to 419 cp15s), MPA (≥420 to 841 cp15s) and VPA (≥842 cp15s cp15s) / Actigraph GT3X+ on hip (#2)	2			
	SB (< 800 cpm), LPA (800–1679 cpm), MPA (1680–3367 cpm) and VPA (≥3368 cpm) / ActiGraph GT3X on hip and activPAL4 on thigh (#1)	1			
	SB (≤100 cpm), LPA (101–799 cpm), MPA (800–1679 cpm), and MVPA (≥1680 cpm) / ActiGraph GT9X on waist (#1)	1			
Trost et al., 2011 (3)	SB (≤100 vertical cpm), LPA (101–2295 vertical cpm) and MVPA (≥2296 vertical) / ActiGraph GT3X on hip (#4)		1	2	
Trost et al., 2012 (3)	SB (< 25 cp15s); LPA (25–420 cp15s) and MVPA (>420 cp15s) / Actigraph GT3X+ on hip (#1), on wrist (#1)	2			
	SB (<1.5 MET) and MVPA (≥3.8 MET) / Actigraph GT3X+ on hip (#1)			1	
Ekblom et al., 2012 (2)	SB (≤ 79 cp15s), LPA (80 to 261 cp15s), MVPA (≥ 262 cp15s) / Actiwatch Spectrum on wrist (#1)	1			
	SB (0-320 cpm), LPA (321-1047 cpm), and MVPA (≥1048 cpm) / Actiwatch Spectrum on wrist (#1)			1	

Butte et al., 2014 (2)	SB (<821 cpm) and MVPA (>3909) / ActiGraph GT3X on hip and Actiheart on chest (#1)	1			
	N.R. / ActiGraph GT3X on wrist (#1)	1			
Puyau et al. 2004 (2)	SB (AEE <0.01 kcal/kg/min), LPA (AEE 0.01 < 0.04 kcal/kg/min), MPA (AEE 0.04 < 0.10 kcal/kg/min), and VPA (>0.10 kcal/kg/min) / Actical on hip (#1)		1		
	SB (< 1.5 PAR), LPA (1.5 - 2.9 PAR), MPA (3.0-6.0 PAR) and VPA (> 6.0) / ActiGraph GT3X on hip (#1)			1	
Romanzini et al. 2014 (2)	SB (0-180 cp15s), LPA (181-756 cp15s), MPA (757-1111 cp15s) and VPA (≥1112 cp15s) / ActiGraph GT3X on hip (#2)			2	
Hildebrand et al., 2017 (2)	SB (ENMO <45 mg); LPA (ENMO ≥45 mg and <100 mg); MVPA (ENMO ≥100 mg); ENMO values were averaged over 5 s epochs / ActiGraph GT9X on wrist (#1), on hip (#1).				1
Esliger et al., 2011. (2)	SB (<188 cpm), LPA (188 cpm), MPA (403 cpm), VPA (1131 cpm) / GENEActiv on wrist (#1)				1
	SB (<241 g/min), LPA (241–338 g min), and MVPA (>338 g min) / GENEActiv on wrist (#1)				1
Shin et al., 2015 (2)	SB (≤ 1.5 MET), LPA (1.5 – 3 MET) and MVPA (>3 MET) / SenseWear Pro 3 Armband on arm (#2)				2
White et al., 2016 (1)	SB (<48 mg), LPA (48 < 154 mg), MPA (154 <389 mg) and VPA (>389 mg) / GENEActiv on wrist (#1).				1
Sasaki et al. 2011 and Aguilar-Farias et al. 2014 (2)	SB (0-199 cpm; Sasaki) and MVPA (>2690 cpm; Aguilar-Farias) / Actigraph GT3X on hip (#2).				2
Rowlands et al. 2018 (2)	SB (<40 mg), LPA (48 < 100 mg), and MVPA (≥100 mg) / GENEActiv on wrist (#1).				1
	SB (<30.0 mg), LPA (>30.0-100.6 mg), and MVPA (>100.6 mg) / Actigraph GT3X on wrist (#1).				1

Hager et al., 2016 (1)	SB (0-40 cpm), LPA (41 2200 cpm), MVPA ($\geq$ 2201 cpm) / Actical on ankle (#1)	1		
Janssen et al., 2003 and Pate et al., 2010 (1)	SB ($\leq$ 25 cp15s), LPA ($>$ 25 cp15s) and MPA ($>$ 420 cp15s) (Janssen); VPA ($>$ 842 cp15s) (Pate) / Actigraph GT3X on hip (#1)	1		
Adolph et al., 2012 and Trost et al., 2010 (1)	SB (0–6 counts cp15s), LPA (7–286 cp15s), MVPA ($\geq$ 287 cp15s) / Actical on waist (#1)	1		
Hjorth et al. 2012 (1)	SB ($\leq$ 25 cp15s), LPA (26–419 cp15s) and MVPA ($\geq$ 420 cp15s) / ActiGraph GT3X on hip (#1)	1		
Chandler et al., 2016, Gavarry et al., 1998 (1)	SB (0%-19.9% HRR) and MVPA ($\geq$ 50% HRR) / Fitbit Charge 2 on wrist (#1)		1	
Philips et al., 2013 (1)	SB (244 g.min), LPA (878 g.min) and MVPA (2175 g.min) / GENEActiv accelerometer on wrist (#1)			1
Sasaki et al., 2011 (1)	SB ($<$ 200 cpm), LPA (200 to $<$ 3028 cpm), MPA ($\geq$ 3028 and $<$ 4448 cpm), VPA ($\geq$ 4448) / ActiGraph GT3X on hip (#1)			1
Kozey-Keadle et al., 2011 and Freedson et al., 1998. (1)	SB ($<$ 150 cpm; Kozey-Keadle), LPA (150 to 1951 cpm) and MVPA ($\geq$ 1952 cpm; Freedson) / ActiGraph GT3X on hip (#1)			1
Crouter et al., 2015. (1)	SB (0-275 cp5s), LPA (276-415 cp5s), MPA ($\geq$ 778 cp5s) and VPA ($\geq$ 416 cp5s) / ActiGraph GT3X on wrist (#1)			1
Hurter et al., 2018 and Hildebrand et al., 2014 (1)	SB/LPA (ENMO 50 mg; Hurter) and MVPA (ENMO 200 mg; Hildebrand) / ActiGraph GT9X on wrist (#1)			1

Chandler et al., 2016 (1)	SB (<305 cp15s), LPA (306–817 cp15s), MPA (818–1968 cp15s), VPA (≥1969 cp15s) / ActiGraph GT9X on wrist (#1)			1	
Payau et al., 2002 (1)	SB (< 100 cpm), LPA (100–1499 cpm) and MVPA (> 1499 cpm) / Actical on hip (#1)			1	
Phillips et al., 2012 (1)	SB (<7 g), VPA (>60 g) / GENEActiv, on wrist (#1)			1	
Hamer et al., 2020 (1)	SB (0 steps), LPA (<100 steps/min), MVPA ≥100 steps/min / ActivPAL3 on thigh (#1)				1
Heil, 2006 (1)	LPA (<3.0 METs), MPA (≥3 to <6.0 METs), VPA (≥6.0 METs) / Actical on waist (#1)				1
Evenson et al., 2015 (1)	SB (<19 cp15s); LPA (19–518 cp15s) and MVPA (≥519 cp15s) / Actigraph GT3X on hip (#1)				1
Vähä-Ypyä et al., 2015 (1)	SB and standing (MAD < 22.5) (LPA (≥ 1.5 and <3.0 (MAD = 22.5 and 91.5 mg)); MVPA (≥ 3.0 (MAD >91.5 mg)) / UKK RM42 on hip (#1)				1
Copeland et al., 2009 and Matthews et al., 2008 (1)	SB (<100 cpm), MVPA (>1040 cpm) / ActiGraph GT3X on hip (#1)				1
Powell et al., 2017 (1)	MVPA (≥ 5123 cp15) / GENEActiv on wrist (#1)				1
Skotte et al., 2014 (1)	SB and LPA (<100 steps per min) and MVPA (>100 steps per min) / ActiGraph GT3X on thigh (#1)				1
Troiano et al. 2008 (1)	SB (0–99 cpm), MVPA (≥2020 cpm) / Actigraph GT3X on hip (#1)				1
Landry et al. 2015 (1)	SB (<178.5 cpm), LPA (178.6–562.4 cpm), and MVPA (>562.4 cpm) / Actiwatch Spectrum on wrist (#1)				1
Winkler et al. 2016 (1)	Algorithm / ActivPAL on thigh (#1)				1

Lee et al. 2019 (1)	SB (< 231 cpm), LPA (232–4514 cpm), and MVPA (> 4515 cpm) / Actigraph GT3X on wrist (#1)				1
Reece et al., 2015 (1)	SB (1.0–1.5 METs); LPA (1.6–2.9 METs) MVPA (≥3.0 METS) / SenseWear armband on arm (#1)				1

Legend: SB: sedentary behavior; PA: physical activity; LPA: light physical activity; MPA: moderate physical activity; VPA: vigorous; MVPA: moderate to vigorous physical activity; TPA: total physical activity; cpm: counts per minute; N.R.: not reported; cp15s: counts per 15 seconds; METs: Metabolic equivalents; ENMO: Euclidean Norm Minus O

Table 5. Most commonly used methods and procedures in studies measuring 24-hour MovBeh with accelerometry

Accelerometer model and placement on the body	• The Actigraph GT3X worn on the wrist in children and adolescents hip (<18 years); • The Actigraph GT3X worn on the hip in children and adolescents hip (<18 years). Some researchers choose to have participants wear one accelerometer on the wrist and another on the hip simultaneously.
Number of days for data collection and number of required valid days; Hours required for a valid day	• 24-hour periods over seven days; • at least three weekdays and one weekend day as valid data; • 16 hours/day per 24-hour period.
Criteria for non-wear time	• ≥ 20 min of consecutive zero counts for studies with children and adolescents; • ≥60 min of consecutive zero counts for adults.
Epochs	• 15 seconds for children and adolescents; • 60 seconds for adults.
Movement behavior outcomes and reporting formats	• Sleep, SB, LPA and MVPA; • Minutes/hours per day/week.
Sleep algorithms	• The Sadeh et al. (1994) for children and adolescents. • Cole-Kripke et al. (1992) for adults.
PA and SB cut points	• Pate et al., 2006 for toddlers and preschoolers; • Evenson et al., 2008 for children; • Hildebrand et al., 2014 and 2017 for adolescents; • Freedson et al., 1998 for adults and older adults.
Procedures handling non-compliant participants	• Exclude non-compliant participants from the analysis.
Use of diaries or logs	• Most of the included studies supplemented accelerometer data with diaries or logs.

7.2. Supplementary files

7.2.1. Supplementary file 1 – Search Strategy

PubMed

((("sedentary behavior"[Mesh] OR "sitting position"[Mesh] OR "screen time"[Mesh] or Sedent*[Title/Abstract]) AND (Sleep[Mesh] OR Sleep[Title/Abstract])) AND (Exercise[Mesh] OR Physical activity[Title/Abstract] OR Energy Expenditure[Title/Abstract] OR "health enhancing physical activity"[Title/Abstract] OR "active play"[Title/Abstract] OR "tummy time"[Title/Abstract] OR "prone position"[Title/Abstract] OR "floor time"[Title/Abstract]))) OR ("Movement Behavi*" [Title/Abstract])

AND

(acceleromet*[Title/Abstract] OR wearable[Title/Abstract] OR "activity monitor"[Title/Abstract] OR actigraph*[Title/Abstract] OR actical[Title/Abstract] OR RT3[Title/Abstract] OR tritrac[Title/Abstract] OR armband[Title/Abstract] OR activpal[Title/Abstract] OR sensewear[Title/Abstract] OR biotrainer[Title/Abstract] OR dynapor[Title/Abstract] OR caltrac[Title/Abstract] OR actiheart[Title/Abstract] OR tracmoor[Title/Abstract] OR genea[Title/Abstract] OR geneactive[Title/Abstract] OR Minilogger[Title/Abstract] OR actiwatch[Title/Abstract] OR actitrac[Title/Abstract] OR hookie[Title/Abstract])

PsycInfo and SportDiscus

("exp sedentary".mp. OR "sedentary behavi*r" OR sedentary OR "sedentariness" OR sedentarism OR "sedentary lifestyle" OR "sitting" OR "inactiv*" OR "physical* inactiv*" OR "low energy expenditure") AND ("exp sleep".mp. OR sleep* OR "sleep time" OR bedtime OR bedtime* OR "wake up time" OR "exp sleep duration".mp. OR sleepiness OR "time in bed" OR "sleep hour*" OR "sleep quantity" OR "insufficient sleep") AND (exp Exercise OR "Energy Expenditure" OR "physical activit*" OR walking OR training OR run* OR swim* OR "active commut*" OR "active behavi?r" OR jog* OR bicycl* OR cycle OR "physical exertion" OR "health enhancing physical activity" OR "recreational activit*" OR "active play".mp. OR "tummy time".mp. OR "prone position".mp. OR "floor time".mp.) OR (Movement Behavio*.mp.)

AND

(acceleromet*.mp. OR wearable.mp. OR "activity monitor".mp. OR actigraph*.mp. OR actical.mp. OR RT3.mp. OR tritrac.mp. OR armband.mp. OR activpal.mp. OR sensewear.mp. OR biotrainer.mp. OR dynapor.mp. OR caltrac.mp. OR actiheart.mp. OR tracmoor.mp. OR genea.mp. OR geneactive.mp. OR Minilogger.mp. OR actiwatch.mp. OR actitrac.mp. OR hookie.mp.)

EMBASE

('exp sedentary':ab,ti OR 'sedentary behavi*r':ab,ti OR sedentary:ab,ti OR sedentariness:ab,ti OR sedentarism:ab,ti OR 'sedentary lifestyle':ab,ti OR sitting:ab,ti OR inactiv*:ab,ti OR 'physical* inactiv*':ab,ti OR 'low energy expenditure':ab,ti) AND ('exp sleep':ab,ti OR sleep*:ab,ti OR 'sleep time':ab,ti OR bedtime:ab,ti OR bedtime*:ab,ti OR 'wake up time':ab,ti OR 'sleep duration':ab,ti OR 'time in bed':ab,ti OR 'sleep hour*':ab,ti OR 'sleep quantity':ab,ti OR 'insufficient sleep':ab,ti) AND (('exp exercise':ab,ti OR 'energy expenditure':ab,ti OR 'physical activit*':ab,ti OR walking:ab,ti OR training:ab,ti OR run*:ab,ti OR swim*:ab,ti OR 'active commut*':ab,ti OR 'active behavi?r':ab,ti OR jog*:ab,ti OR bicycl*:ab,ti OR cycle:ab,ti OR 'physical exertion':ab,ti OR 'health enhancing physical activity':ab,ti OR 'recreational activit*':ab,ti

OR 'active play':ab,ti OR 'tummy time':ab,ti OR 'prone position':ab,ti OR 'floor time':ab,ti) OR ('movement behavior':ab,ti)

AND

('exp accelerometer':ab,ti OR wearable:ab,ti OR 'activity monitor':ab,ti OR actigraph*:ab,ti OR actica:ab,ti OR RT3:ab,ti OR tritrac:ab,ti OR armband:ab,ti OR activpal:ab,ti OR sensewear:ab,ti OR biotrainer:ab,ti OR dynapor:ab,ti OR caltrac:ab,ti OR actiheart:ab,ti OR tracmoor:ab,ti OR genea:ab,ti OR geneactive:ab,ti OR Minilogger:ab,ti OR actiwatch:ab,ti OR actitrac OR hookie:ab,ti)

7.2.2. Supplementary file 2 – Individual results

Table S1. Characteristics of individual reports

Authors and year	Country; Study	Type of study	N	Age	Gender (% of girls/woman)
Toddlers (2-3 years)					
Armstrong et al. 2019 ¹	USA; N.R.	Cross-sectional	101	12 to 32 months	39%
Santos et al., 2017 ²	Australia; GetUp study)	Cross-sectional	202	12 to 28 months	51.5%
Haines et al. 2018 ³	Canada; The Guelph Family Health Study)	RCT	42	18 to 60 months	N.R.
Preschoolers (3-5 years)					
Alonso-Martínez et al. 2021 ⁴	Spain; N.R.	Cross-sectional	268	4 to 6 years	46.6%
Chang et al. 2021 ⁵	China; N.R.	Cross-sectional	458	3 to 6 years	50.6%
Chen et al., 2020 ⁶	Singapore; Growing Up in Singapore Towards healthy Outcomes (GUSTO)	Cross-sectional	552	5 years	48%
Craemer et al., 2021 ⁷	Belgium; N.R.	Cross-sectional	16	3 to 5 years	50%
Duraccio et al., 2017 ⁸	USA; N.R.	Cross-sectional	131	4 to 6 years	43.5%
Ng et al., 2021 ⁹	China; SUNRISE	Cross-sectional	25	4.4 (0.3) years	N.R.
Tomaz et al., 2019 ¹⁰	South Africa; N.R.	Cross-sectional	78	3 to 5 years	50%

Meredith-Jones et al., 2019 ¹¹	New Zealand; Prevention of Overweight in Infancy (POI) study	Longitudinal	547	1, 2 and 5 years	N.R.
Laurent et al., 2020 ¹²	USA; N.R.	Longitudinal	288	3 to 5 years	47.2%
Williams et al., 2014 ¹³	New Zealand; FLAME - Family Lifestyle, Activity, Movement and Eating	Cross-sectional	234	3 to 7 years	42.74%
Butte et al., 2016 ¹⁴	China; N.R.	Cross-sectional	254	≥ 4.0 years [4.1 (6.3) years]	46.9%
Hossain et al. 2021 ¹⁵	Bangladesh; SUNRISE study	Cross-sectional	65	3 to 5 years [4.5 (0.3)]	47.8%
Kang et al. 2021 ¹⁶	USA; N.R.	Cross-sectional	30	3 to 5 years [3.8 (1.0)]	43.0%
Kuzik et al. 2020 ¹⁷	Canada; The Parent-Child Movement Behaviours and Pre-School Children's Development study	Cross-sectional	95	3 to 5 years [4.5 (0.07)]	30.5%
Guan et al. 2020 ¹⁸	USA; N.R.	Longitudinal	111	3 to 5 years	47.75%
Children (5-10 years)					

Manyanga et al., 2019 ¹⁹	Australia, Brazil, Canada, China, Colombia, Finland, India, Kenya, Portugal, South Africa, the UK and USA; International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE)	Cross-sectional	8,055	9–11 years	54.7%
Ekstedt et al., 2013 ²⁰	Sweden; The Stockholm Obesity Prevention Project (STOPP)	Cross-sectional	1,231	6-10 years	N.R.
Padmapriya et al., 2021 ²¹	Singapore; GUSTO study	Longitudinal	634	5.5 and 8 years	48.4%
Taylor et al., 2020 ²²	New Zealand; N.R.	Cross-sectional	690	6 to 10 years	51.5%
Vuholm et al., 2021 ²³	Denmark; Fish, children, health, and cognition (FiSK)	RCT	194	8 to 9 years	50%
Burkart et al., 2021 ²⁴	USA; N.R.	Quasi-experimental	231	7 to 12 years	47%
Haszard et al.,	New Zealand;	Cross-	742	8.0 (1.1)	51.4%

2020 ²⁵	PLAY study	sectional			
Toledo-Vargas et al., 2020 ²⁶	Chile; N.R.	Cross-sectional	258	9 to 11 years	50.5%
Armstrong et al., 2021 ²⁷	USA; N.R.	Cross-sectional	196	5 to 10 years	53%
Fairclough et al., 2017 ²⁸	UK; Active Schools: Skelmersdale (AS:Sk) study	Cross-sectional	169	9 to 10 years	50.3%
Hjorth et al., 2016 ²⁹	(Denmark; OPUS Optimal well-being, development, and health for Danish children through a healthy New Nordic Diet School Meal Study	Cross-sectional	828	8 to 11 years	49%
Moreno et al., 2021 ³⁰	USA; N.R.	Longitudinal	119	5 to 8 years	57%
Antczak et al., 2021 ³¹	Australia; Internet-based professional Learning to help teachers support Activity in Youth” (iPLAY)	Longitudinal	1059	8 to 9 years	50%
García-Alonso et al., 2022 ³²	Spain; Observatorio de Actividad Física en escolares de	Longitudinal	110	4 to 7 years	50.91%

3 a 9 años					
Hedayatrad et al. 2022 ³³	New Zealand; Growing Up in New Zealand study (GUINZ)	Cross-sectional	623	8.0 years [7.8 (0.2)]	51.5%
Lucas-de la Cruz et al. 2018 ³⁴	Spain; Prevention of excess weight in schoolchildren (MOVI-2)	Cross-sectional	146	8 to 11 years [9.4 (0.7)]	54.8%
Martinez et al. 2019 ³⁵	USA; N.R.	Longitudinal	308	8 to 10 years [8.9 (0.8)]	53.0%
Adolescents (10-17 years)					
Caetano et al. 2021 ³⁶	Brazil; N.R.	Cross-sectional	309	14 to 16 years	57%
Chong et al. 2021 ³⁷	Australia; N.R.	Longitudinal	88	10 to 13 years	59.1%
Costa et al., 2020 ³⁸	Brazil; Estudo Longitudinal do Estilo de Vida de Adolescentes' (ELEVA)	Cross-sectional	688	14–18 years	50.4%
Dumuid et al., 2021 ³⁹	Australia; Child Health CheckPoint data and Longitudinal Study of Australian Children	Cross-sectional	1,182	11 to 12	49%

(LSAC)					
Negele et al., 2020 ⁴⁰	Germany; GINIplus and LISA studies	Longitudinal	1223	15 years	55%
Tye et al; 2020	Tye et al., 2020 New Zealand; N.R.	Cross-sectional	119 girls	15 to 18 years	NA
Van Dyk et al., 2018 ⁴¹	USA; N.R.	Randomized intervention without control	18	14 to 17 years	66.7%
Fairclough et al., 2021 ⁴¹	UK; N.R.	Cross-sectional	359	9 to 13 years	50.7%
Collings et al., 2015 ⁴²	UK; the ROOTS study	Cross-sectional	144	15 to 17.5 years	50%
Gába et al., 2020 ⁴³	Czech Republic; N.R.	Cross-sectional	659	8 to 18 years	58%
Talarico et al., 2018 ⁴⁴	Canada; N.R.	Cross-sectional	434	10 to 13 years	50.2%
Starbek et al., 2022 ⁴⁵	Slovenia; N.R.	Cross-sectional	51	15 to 19 years	51%
Grant et al. 2020 ⁴⁶	USA; N.R.	Cross-Sectional	36	N.R (6th to 8th grades)	58.3%
Krietsch et al. 2022 ⁴⁷	USA; N.R.	Longitudinal	90	14-17 years [15.7 (1.1)]	67.0%
Master et al. 2017 ⁴⁸	USA: The Fragile Families & Child Wellbeing Study (FFCWS)	Cross-sectional	417	15 years [15.5 (0.6)]	53.0%

Merikanto et al. 2020 ⁴⁹	Finland; The Genome-wide association study (GWAS)	Longitudinal	353	12 years [12.3 (0.5)]	53.0%
Beltran-Valls et al., 2021 ⁵⁰	Spain; DADOS (Deporte, ADOlescencia y Salud)	Longitudinal	189	13.9 (0.3) years	48.2%
Domingues et al., 2022 ⁵¹	Brazil; N.R.	Cross-sectional	185	15 to 18 years	49.2%
Harrington et al., 2021 ⁵²	UK; N.R.)	Cross-sectional	816 girls	11 to 14 years	NA
Aguilar-Farias et al., 2020 ⁵³	Chile; ESPACIOS	Cross-sectional	148	9 to 11 years	52.7%
Butte et al., 2007 ⁵⁴	USA; VIVA LA FAMILIA Study	Cross-sectional	897	4 to 19 years	50.8%
Kim et al., 2020 ⁵⁵	USA; N.R.	Cross-sectional	263	12.24 (0.99) years	48.7%
Adults and older adults (≥ 18 years)					
Ataka et al. 2022 ⁵⁶	Japan; N.R.	Cross-sectional	56	74.2 (3.9)	58.9%
Betson et al. 2022 ⁵⁷	Australia; N.R.	Cross-sectional	28	25.5 (4.5)	53.6%
Blodgett et al. 2022 ⁵⁸	UK; 1970 British Cohort Study	Cross-sectional	6,562	45 yrs	N.R.
Booth et al. 2012 ⁵⁹	USA; N.R.	Cross-sectional	48	21 to 40	56.3%

Buman et al. 2016 ⁶⁰	USA; N.R.	Longitudinal	20	35 to 65	15%
Cabanas-Sánchez et al. 2019 ⁶¹	Spain; Seniors-ENRICA-2 study	Cross-sectional	3273	65 to 94 years	53.1%
Carneiro-Barrera et al. 2020 ⁶²	Spain; N.R.	Cross-sectional	187	18-25 years	64.7%
Dumuid et al., 2018 ⁶³	Australia; N.R.	Cross-sectional	122	60 to 70	61%
Ellingson et al., 2018 ⁶⁴	USA; N.R.	Cross-sectional	271	21 to 35 years	48.7%
Full et al., 2020 ⁶⁵	USA; Women's Health Initiative OPACH Study	Cross-sectional	3,329 women	63 to 99 years	NA
Liao et al., 2020 ⁶⁶	USA; N.R.	Longitudinal	105	23 to 68 years	95%
Millard et al., 2021 ⁶⁷	UK; UK BIOBANK	Longitudinal	79,503	40 to 69 years	54.5%
Mochón-Bengui et al., 2021 ⁶⁸	Spain; FIT-AGEING study«	Cross-sectional	74	40–65 years	52.7%
Park et al., 2022 ⁶⁹	USA; N.R.	Cross-sectional	75 women	18 to 75 years	NA
Suorsa et al., 2022 ⁷⁰	USA; Physical Activity Measurement Survey (PAMS)	Cross-sectional	1,235	21 to 70	56.6%
Curtis et al., 2020 ⁷¹	Finland; Finnish Retirement and Aging	Longitudinal	551	63.3 (1.1) years	86%

	Study (FIREA)				
Cabanas-Sanchez et al., 2018 ⁷²	Australia; Active Team	Cross Sectional	430	18 to 65 years	74%
Husu et al., 2021 ⁷³	Spain; IMPACT65+	Cross Sectional	607	65 to 92 years	65.7%
Knaeps et al., 2017 ⁷⁴	Finland; FinFit 2017 study	Cross Sectional	2,256	20 to 69 years	59%
Mitchell et al., 2016 ⁷⁵	Belgium; N.R.	Cross Sectional	410	29 to 82 years	36%
Powell et al., 2020 ⁷⁶	USA; Nurses Health Study II	Cross Sectional	353 women	21 to 75 years	N/A
Gupta et al., 2020 ⁷⁷	(Denmark; Physical wOrk Demands and Prospective register-based Sickness Absence study (PODESA) cohort; 'Danish Physical ACTivity cohort with Objective measurements' (DPhacto);	Longitudinal	929	44.9 (9.7)	45%

	‘New method for Objective Measurements of physical Activity in Daily living’ (NOMAD) cohort.)				
Verhoog et al., 2020 ⁷⁸	Netherlands; Rotterdam Study	Cross-Sectional	1,954	51 to 94 years	51.5%
Full et al., 2019 ⁷⁹	USA; Transdisciplinary Research in Energetics and Cancer (TREC)	Cross-Sectional	372 women	21–75 years [55.38 (10.16)]	N/A
Galmes-Panades et al. 2019 ⁸⁰	Spain; The PREDIMED-Plus study	Cross-Sectional	2189	55–75 years [65.0 (4.95)]	47.1%
German et al. 2020 ⁸¹	USA; Multi-Ethnic Study on Atherosclerosis [MESA] Sleep Ancillary Study)	Cross-Sectional	1718	45–84 years [68 (n.r.)]	54.0%
Gilson et al. 2021 ⁸²	Australia; Truck-Fit study	RCT	37 men	Age range N.R. 45.9 (10.2)	N/A
Goncin et al. 2020 ⁸³	Canada; N.R.	Longitudinal	28	> 60 years [69.7 (6.5)]	50.0%
Gubelmann et	Switzerland; CoLaus	Cross-	2649	45–86 years [61.6	53.5%

al. 2018 ⁸⁴	study	sectional		(9.8)]	
Gupta et al. 2018 ⁸⁵	Denmark; DPHACTO cohort	Cross-sectional	827	≥ 18 years [45 (10) years]	46.2%
Hargens et al. 2021 ⁸⁶	USA; N.R.	Cross-sectional	81	N.R. [20.2 (1.5)]	65.0%
Heiland et al. 2021 ⁸⁷	Sweden; Physical Activity and Healthy Brain Functions	Cross-sectional	324	≥ 18 years [42.4 (9.0)]	62.7%
Imes et al. 2021 ⁸⁸	USA; EMPOWER Study	Cross-sectional	108	≥ 18 years [51.2 (10.6)]	88.9%
Le et al. 2021 ⁸⁹	(Australia; ACES, DESTRESS, and SHS)	Cross-Sectional	361	≥ 18 years [22.6 (5.3)]	72.6%
Lee et al. 2020 ⁹⁰	USA; Healthy Women Study	Cross-Sectional	136 women	42-50 years [73.3 (1.7)]	N.A.
Madden et al. 2014 ⁹¹	Canada; N.R.	Cross-Sectional	51	≥ 65 years [71.5 (0.6)]	52.9%
McDonough et al. 2022 ⁹²	USA; N.R.	RCT	96	18 - 35 years [22.9 (3.7)]	75.0%
Meyer et al. 2020 ⁹³	USA; The Energy Balance Study	Longitudinal	348	20-35 years [27.7 (3.7)]	50.0%
Pasanen et al. 2022 ⁹⁴	Finland; REACT	RCT	345	N.R. [65.2 (1.1)]	82.3%
Seol et al., 2019 ⁹⁵	Japan; N.R.	Cross-Sectional	70	65 to 84 years	77.1%

Tigbe et al., 2017 ⁹⁶	UK; N.R.	Cross- Sectional	111	22 to 60 years	13.5%
Wang et al., 2022 ⁹⁷	Sweeden; N.R.	Single-blind, parallel- group, randomized trial	245	18 to 70 years	73.1%
Santos et al., 2021 ⁹⁸	Brazil; N.R.	Longitudinal	27	At least 15	60%

Table S2. Results of individual reports

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
Toddlers (2-3 years)								
Armstrong et al. 2019 ¹	Actical on non-dominant ankle, nonremovable; Actical software.	3-7 days; ≥ 3 days with a daily average of 80 counts per minute, including 1 weekend day (24 h).	N/A	1-min epoch.	Sleep duration (Hours/day). SB, LPA, MPA, VPA and TPA (min/day).	Sleep duration (Total sleep time: number of minutes asleep between sleep onset and sleep offset.; Daytime napping: 30 successive epochs of sleep that occurred between 09:00 and 17:00.); Sleep algorithm (Sadeh et al., 1994) ⁹⁹ , assisted by log. SB (0-40 cpm), LPA (41 2200 cpm), MVPA (≥ 2201 cpm); Hager et al. 2016 ¹⁰⁰ .	Participants who responded to 5 or fewer survey prompts with corresponding Actical data were excluded.	Ecological momentary assessment for sleep.
Santos et al., 2017 ²	Actigraph GT3X+ on right hip; ActiLife.	7 days; ≥ 1 24h period.	Through manually and visually Screened.	Sampled at 30 Hz and reintegrated into 15-s epoch.	Sleep, SB, LPA, MVPA, TPA (min/day).	Sleep duration (including nighttime and daytime naps) was manually and visually screened, considering log and accelerometer files. SB (< 25 cp15s); LPA (25–420 cp15s) and MVPA (>420 cp15s); Trost et al., 2012 ¹⁰¹ .	Non-compliant participants were excluded from the analyses.	Sleep and non-wear time diary

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
Haines et al. 2018 ³	ActiGraph GT3X on non-dominant wrist; Actilife	7 days (except water-based activities); ≥3 days (N.R.)	Choi's algorithm ¹⁰²	1-sec epochs	Sleep, SB, LPA, and MVPA (min/day)	Sleep (duration) defined by algorithm Sadeh and Tudor-Locke algorithms. SB, LPA, and MVPA (N.R.). < 3 years - Trost et al. 2012 ¹⁰¹ ≥ 3 years - Butte et al. 2014 ¹⁰³	Non-compliant participants were excluded from the analyses.	No
Preschoolers (3-5 years)								
Alonso-Martínez et al. 2021 ⁴	GENEActiv tri-axial on non-dominant wrist; GGIR package in R	6 days; 6 days (≥600 min during awake time and an average sleep time ≥200 min)	N.R.	Raw data were sampled at 87.5 Hz and then reintegrated into 1-s epochs	Sleep duration (Hours/day) SB, LPA, MPA, VPA and TPA (min/day)	Sleep (sleep onset to offset) defined by the algorithm Hees et al. 2015 ¹⁰⁴ . SB, LPA, MPA and VPA TPA (total recorded counts/wear time) ¹⁰⁵	Non-compliant participants were excluded from the analyses.	No
Chang et al. 2021 ⁵	ActiGraph GT3X-BT on right hip; ActiLife	7 days except in water activities; 4 days including 1 weekend day (≥1,000 min/day)	Choi algorithm	15-s epoch	Sleep, SB, LPA, MVPA, TPA (min/day)	Sleep (Sleep duration: Visual diagnosis by experts per minute) defined by algorithm Tudor-Locke (2014) ¹⁰⁶ , and mode of low frequency extension: SB (0–467 cp15s), LPA (468–2,207 cp15s); MPA (2,208–3,991 cp15s) and VPA (≥3,992 cp15s); The origin of these cut-off points is not clear.	Non-compliant participants were excluded from the analyses.	No use

ID - Authors and year (Country/ study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
Chen et al., 2020 ⁶	ActiGraph wGT3X-BT on non-dominant wrist, nonremovable; Actilife	7 days, 2 weekdays and 1 weekend day (16h/day)	Non-wear time was estimated based on the standard deviation and value range of each accelerometer axis, using a 60-min window with 15-min increments.	80 Hz	Sleep, SB, LPA and MVPA (h/day)	Sleep (Sleep duration) defined by the algorithm (Hees et al., 2015) ¹⁰⁴ . SB (≤ 35 mg), LPA (35–200 mg and MVPA (>200 mg); ENMO values were averaged over 5 s epochs, Hildebrand et al., 2014 ¹⁰⁷ and 2017 ¹⁰⁸ .	The invalid data were imputed using the mean value of valid data at same time points on other days	No use
Craemer et al., 2021 ⁷	ActivPAL on right anterior thigh midway and the Axivity on non-dominant wrist; ActivPAL; Open Movement software	7 days, except in water activities (just for Axivity; N.R. (N.R.))	N.R.	1-min epoch	Sleep, SB, TPA (% of 24h)	Sleep (Time in bed: start time and end time) defined by the algorithm. SB (If more than 45 s of the 60 s epoch were spent sitting or lying, this epoch was classified as SB) Activity (Yes if there was no SB and no Sleep) (VANE algorithm)	Non-compliant participants were excluded from the analyses.	No use
Duraccio et al., 2017 ⁸	Actigraph GT3X+ on right hip; ActiLife and	3 days; N.R. (≥ 8 h/day of PA.	If no movement was recorded during the night, it was assumed that the	15-s epoch.	Sleep (h/day).	Sleep (Sleep duration) defined by algorithm (Sadeh et al., 1994) ⁹⁹ .	Non-compliant participants were excluded from the	Parents reported their child's typical bedtime and

ID - Authors and year (Country/ study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
	MeterPlus4.		accelerometer was removed prior to bedtime. 60 consecutive min of nonmovement was defined as an invalid hour.		SB, MPA and VPA (min/day).	SB (0-199 cp15s), MPA (420-841 cp15s) and VPA (≥ 842 cp15s); Pate et al., 2006 ¹⁰⁹ .	analyses.	wake time during the week on the demographics survey.
Ng et al., 2021 ⁹	ActiGraph wGT3X-BT on right hip	5 days, except in water activities; 2 days (all sleep and 8 h/day)	20 min or more of consecutive zeros	Sampled at 30 Hz which was integrated into 15 s epochs.	Sleep, SB, LPA, MVPA (min/day).	Sleep (determined through visual inspection of the acceleration graphs) SB (≤ 199), LPA (≥ 200 to 419), MPA (≥ 420 to 841 cp15s) and VPA (≥ 842 cp15s); Pate et al., 2006 ¹⁰⁹ .	Non-compliant participants were excluded from the analyses.	Parents reported sleep timings sedentary screen time, total PA, MVPA, and the time children spent outdoors at both time points using questionnaires .
Tomaz et al., 2019 ¹⁰	Actigraph GT3X+ on right hip; Actilife	7 days, except in water activities; ≥ 3 weekdays and ≥ 1 weekend day (≥ 7 waking hours for PA;	20 minutes of consecutive zeroes and was excluded from daytime and nocturnal analyses	Sampled at 80 Hz and converted to 15-s epoch for PA and 1-min epoch for sleep	Sleep (h/day). SB, LPA, MPA, VPA (min/day).	Sleep (nap times were identified during the daytime by visual inspection; Nocturnal sleep: by visual inspection); (Chow et al., 2016) ¹¹⁰	Non-compliant participants were excluded from the analyses.	Naps daily schedules of the preschools were used.

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
		(>160 min for sleep)				SB (≤ 25 cp15s), LPA (> 25 cp15s) and MPA (> 420 cp15s); Janssen et al., 2003 ¹¹¹ and VPA (> 842 cp15s); Pate et al., 2010 ¹¹²		Sleep diary was not used.
Meredith-Jones et al., 2019 ¹¹	Actical on hip; MATLAB	7 days; 3 days (≥ 8 waking hours)	At least 20 min of consecutive zeros (Esliger et al., 2005) ¹¹³ .	15-s epochs.	Sleep, SB, TPA (min/day).	Sleep (sleep onset, as the start of the first 15 continuous minutes of sleep preceded by 5 min of awake, to offset, as the last of 15 continuous minutes of sleep followed by 5 min of awake. Matlab script defines naps during daytime wake periods (9 a.m.–5 p.m.) as at least 30 min of continuous sleep, preceded by 5 min of awake). SB (0–6 counts cp15s), LPA (7–286 cp15s), MVPA (≥ 287 cp15s); There is no cut points for this age range, but the presented ones were based on Adolph et al., 2012¹¹⁴ and Trost et al., 2010¹⁰¹	Non-compliant participants were excluded from the analyses.	No use
Laurent et al., 2020 ¹²	Actiwatch Spectrum on non-dominant wrist; Actiware software	16 days; N.R. (≥ 480 min of wear time and full night)	Off-wrist detection with a button to mark events in the record	Sampled at 32 Hz and converted in 15-s epoch	Sleep, SB, LPA, MVPA (min/day)	Sleep (nap, nighttime and total sleep duration) was defined by combination of sleep diaries and button-marked events. If sleep diary entries or event markers were unavailable, the first three consecutive minutes of sleep	Non-compliant participants were excluded from the analyses.	Sleep diary

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
						were used to define sleep onset, and the last five consecutive minutes of sleep defined sleep offset for sleep episodes. SB (≤ 79 cp15s), LPA (80 to 261 cp15s), MVPA (≥ 262 cp15s); Ekblom et al., 2012¹¹⁵		
Williams et al., 2014 ¹³	Actical on hip; Actilife.	5 days including 2 weekend days (N.R.)	at least 20 consecutive minutes of zero counts (Cliff et al., 2009) ¹¹⁶ .	15-s epoch.	Sleep, SB, LPA, MVPA (h/day)	Sleep (duration) was defined by algorithm (Sadeh et al., 1994)⁹⁹. SB (0–47 cpm), LPA (48–2031 cpm), MPA (2032–2875 cpm), VPA (≥ 2876); Evenson et al., 2008¹¹⁷.	Data were excluded if the total counts for the day were less than 10,000 or more than 20 million total counts	Sleep diary completed by parents.
Butte et al., 2016 ¹⁴	ActiGraph GT3X on right hip and Actiheart on chest; N.R.	7 days except in water activities; 4 days including 1 weekend day (≥ 1000 min/day)	20 min or more of consecutive zero counts, if the interval was not identified as nighttime sleep, nap time, or device removal for bathing	1-min epoch	Sleep, SB, MVPA (min/day)	Sleep (Sleep onset was identified by inactivity (counts usually zero) and a gradual decline in heart rate. Sleep termination was identified by abrupt increases in activity and heart rate. This was supported with visually screening) SB (<821 cpm) and MVPA (>3909);	Non-compliant participants were excluded from the analyses.	Sleep and non-wear diary.

ID - Authors and year (Country/ study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
			or aquatic activities in the records completed by the parents.			Butte et al., 2014 ¹⁰³		
Hossain et al. 2021 ¹⁵	ActiGraph wGT3X-BT on the right hip and activPAL4 on the right thigh; Actilife	4 days, except water-based activities; 1 day (≥6 waking h/day)	≥ 20 min of consecutive zero counts and by visual inspection of the ActiGraph data	Sampled at 30 Hz and integrated into 15-s epochs	Sleep, SB, LPA, and MPA (min/day)	Sleep (Manually and visually screened, considering log and accelerometer files) SB (< 800 cpm), LPA (800–1679 cpm), MPA (1680–3367 cpm) and VPA (≥3368 cpm; Pate et al., 2006 ¹⁰⁹)	Non-compliant participants were excluded from the analyses.	Parents reported sleep timings, screen time, total PA, MVPA, and the time children spent outdoors at both time points using questionnaires
Kang et al. 2021 ¹⁶	ActiGraph GT3X+ on hip; Actilife	5 days (24h), except water-based activities; 5 days including 2 weekend days and 3 weekdays (10 waking h/day)	≥ 20 min of consecutive zero counts outside the hours of bedtime and waketime	Sampled at 30 Hz and integrated into 5-s epochs	Sleep, SB, LPA, and MPA (min/day)	Sleep (duration) defined by Algorithm (Hjorth et al. 2012) ¹¹⁸ SB, LPA, and MVPA (N.R.) Freedson et al. 1998 ¹¹⁹	Non-compliant participants were excluded from the analyses.	Sleep diary
Kuzik et al. 2020 ¹⁷	ActiGraph wGT3X-BT on the right hip; R	7 days (24h), except water-based activities; ≥3 days (≥10	≥ 20 min of consecutive zero counts outside the hours of bedtime	Sampled at 30 Hz and integrated into 5-s	Sleep, SB, LPA, and MPA (min/day)	Sleep (duration) defined by Algorithm (Hjorth et al. 2012) ¹¹⁸ .	Non-compliant participants were excluded from the	sleep and accelerometer wear time log

ID - Authors and year (Country/ study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
	software	waking h/day)	and waketime	epochs		SB (≤ 25 cp15s), LPA (26–419 cp15s) and MVPA (≥ 420 cp15s); Hjorth et al. 2012 ¹¹⁸	analyses.	
Guan et al. 2020 ¹⁸	ActiGraph GT9X on hip (24h); Actilife	3 days (except water-based activities); 1 day (24h)	20 min of consecutive zero counts	15-s epochs	Sleep, SB, Screen time, LPA, MPA and VPA (min/day)	Sleep (at least 10 consecutive minutes with a vector magnitude > 0). SB (≤ 100 cpm), LPA (101–799 cpm), MPA (800–1679 cpm), and MVPA (≥ 1680 cpm). Pate et al. 2006 ¹⁰⁹	Those with < 24 h period were excluded	Activity log (including nap(s), bedtime, wake-up time, and accelerometer non-wear time); Screen time parent-report questionnaire
Children (5-10 years)								
Manyanga et al., 2019 ¹⁹	ActiGraph GT3X+ on right side of waist; ActiLife.	7 days except in water activities; ≥ 3 weekdays and ≥ 1 weekend day (10 h/day). For sleep, the criteria were: ≥ 3	Any sequence of ≥ 20 consecutive minutes of 0 activity counts.	Sampled at 80 Hz, downloaded in 1-s Epochs, and reintegrated to 15- and	Sleep, SB and MVPA (h/day).	Sleep (sleep period time: sleep onset to sleep offset) defined by algorithm (Tudor-Locke et al. 2014) ¹⁰⁶ . SB (≤ 25 cp15s), LPA (26–573 cp15s)	No wear time was excluded.	No use.

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
		weekdays and ≥1 weekend, with valid data (total Sleep period time ≥160 min per night and >90% estimated wear time).		60-s epochs for analysis.		and MVPA (≥574 cp15s); Consistent with Evenson et al. 2008 ¹¹⁷ .		
Ekstedt et al., 2013 ²⁰	Actiwatch 4 on wrist; N.R.	7 days, except in water activities; N.R. (N.R.).	sequences during the waking hours indicated ten or more consecutive minutes of zero counts.	1-min epoch.	SB, LPA, MVPA (min/day).	Sleep (Total sleep time: the sum (in minutes) of all sleep epochs between sleep onset and sleep end) defined by algorithm model (Cole et al., 1992) ¹²⁰ . SB (<1.5 METs or < 332 cpm), LPA (1.5 to 3 METs or 332 to 1004 cpm), MPA (3 to 6 METs or 1004 to 2336 cpm) and VPA (> 6 METs or > 2336 cpm); N.R..	No wear time was excluded from the analyses.	No use.
Padmapriya et al., 2021 ²¹	ActiGraph wGT3X on non-dominant wrist, nonremovable; Actilife.	7 days, 2 weekdays and 1 weekend day (16h/day).	Non-wear time was estimated based on the standard deviation and value range of each	80 Hz.	Sleep, SB, LPA, MPA and VPA (min/day).	Sleep (Sleep duration) defined by the algorithm (Hees et al., 2018) ¹²¹ . SB (ENMO ≤35 mg), LPA (ENMO 35–	For each 15-min period detected as non-wear time over the valid	No use.

ID - Authors and year (Country/ study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
			accelerometer axis, using a 60-min window with 15-min increments.			200 mg), MPA (ENMO 200 to 707 mg) and VPA (ENMO ≥ 707 mg); ENMO values were averaged over 5 s epochs, Hildebrand et al., 2014 ¹⁰⁷ and 2017 ¹⁰⁸ .	wearing days, the invalid data were imputed using the mean value of valid data at same time points on other days.	
Taylor et al., 2020 ²²	ActiGraph GT3X on right hip; ActiLife.	8 days; 3 days (≥ 20 h/day).	at least 20 min of consecutive zeros during awake time data only.	15-s Epoch.	Sleep, SB, LPA, MVPA (% of 24h period).	Sleep duration defined by the algorithm (Meredith-Jones et al., 2016) ¹²² . SB (≤ 25 cp15s), LPA (26–573 cp15s) and MVPA (≥ 574 cp15s); Consistent with Evenson et al. 2008 ¹¹⁷ .	No wear time was excluded from the analyses.	No use.
Vuholm et al., 2021 ²³	ActiGraph GT3X +or GT3X on right hip; ActiLife.	7 days, except in water activities; 3 weekdays and 1 weekend day (≥ 9 waking h/day).	Was removed by the algorithm provided by ActiLife.	1-min epoch.	Sleep, SB, LPA and MVPA (min day). TPA (cpm).	Sleep duration defined by the algorithm (Sadeh et al., 1994) ⁹⁹ . SB (≤ 100 vertical cpm), LPA (101–2295 vertical cpm) and MVPA (≥ 2296 vertical cpm); Evenson et al., 2008 ¹¹⁷	Nights where the monitor was reported to have been removed were excluded from the analyses of sleep as were nights with no	Sleep and non-wear time diary.

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
					Steps (min-1).		recorded activity and nights with a sleep duration ≥ 15 h.	
Burkart et al., 2021 ²⁴	FitBit Charge 2 on wrist; FitBit app and Fitabase plataform	6 weeks; 3 weekdays and 1 weekend day. (10 waking hours/day)	N.R.	N.R.	Sleep, SB, LPA, MVPA (min/day)	Sleep (Nocturnal sleep: sleep period lasting >240 min with sleep onset between 7 PM and 6 AM, and offset between 5 AM and 1 PM. Other periods, sleep was considered invalid) PA intensity was calculated from heart rate data: SB (0%-19.9% HRR), LPA (20%-49.9% HRR) and MVPA ($\geq 50\%$ HRR);	No wear time was excluded from the analyses.	No use
Haszard et al., 2020 ²⁵	Actigraph GT3X on right hip; Actilife	7 days, except in water activities; 3 days (10 waking h/day and if the total time was between 20 and 28 hours)	At least 20 min of consecutive zeros.	15-s epochs.	Sleep, SB, LPA, MVPA (min/day)	Sleep (Sleep period) defined by automated script (Meredith-Jones et al., 2016) ¹²² . SB (≤ 25 cp15s), LPA (26–573 cp15s) and MVPA (≥ 574 cp15s); Evenson et al. 2008 ¹¹⁷ .	Non-wear time was reallocated to other day-time components (sedentary, LPA, and MVPA) by multiplying the proportions of day-time wear by total	No use.

ID - Authors and year (Country/ study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
							daytime in minutes.	
Toledo-Vargas et al., 2020 ²⁶	ActiGraph GT3X+ on waist; ActiLife.	7 days, except in water activities; ≥ 4 days, including 1 weekend day (≥10 waking h/day with their respective sleeping periods).	Filter (Tudor-Locke et al., 2015) ¹²³ .	1-min epoch.	Sleep and SB (h/day) MVPA (min/day)	Sleep defined by algorithm (Barreira et al., 2015) ¹²⁴ . SB (0.90– 0.98 area under the receiving operating characteristic curve), LPA (0.70 area under the receiving operating characteristic curve), MPA (0.74–0.85 rea under the receiving operating characteristic curve) and VPA (0.83–0.90 rea under the receiving operating characteristic curve); Evenson et al., 2008 ¹¹⁷ .	No wear time was excluded from the analyses.	No use
Armstrong et al., 2021 ²⁷	Fitbit Charge 2 on non-dominant wrist; Fitabase.	8 days; N.R. (≥10 waking h/day and with step estimates between 1000 and 30,000 steps)	N.R.	1-s epoch for PA and 1-min epoch for sleep	Sleep, SB and MVPA (min/day)	Sleep (Nocturnal sleep: >160 consecutive minutes classified as “asleep” between 7:00 pm and 11:58 am). PA intensity was calculated from heart rate data: SB (0%-19.9% HRR) and MVPA (≥ 50% HRR); Chandler et al., 2016, Gavarry et al., 1998.	No wear time was excluded from the analyses.	No use

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
Fairclough et al., 2017 ²⁸	ActiGraph GT9X on non-dominant wrist; ActiLife	7 days, except in water activities; 3 days (16 h/day)	Non-wear was estimated on the basis of the standard deviation and value range of each accelerometer axis, calculated for moving windows of 60 min with 15 min increments.	Sampled at 30 Hz and converted in 1-s epoch.	Sleep, SB, LPA and MVPA (min/day).	Sleep defined by the algorithm (Hees et al., 2015) ¹⁰⁴ . SB/LPA (2 METs) and MVPA (4 METs) Hildebrand et al., 2014 ¹⁰⁷	For each 15 min period detected as non-wear time over the valid days, missing data were replaced by the mean value calculated from measurement on other days at the same time of day.	Non-wear time diary
Hjorth et al., 2016 ²⁹	ActiGraph GT3X+ or GT3X on right hip; ActiLife	7 days except in water activities; ≥3 weekdays and ≥1 weekend day (≥ 10 waking h/day)	periods of at least 15 min of consecutive zero counts using tri-axial vector magnitudes	1-min epoch	Sleep, SB, LPA. MVPA (min day); TPA (cpm)	Sleep (Sleep duration) was defined by the algorithm (Sadeh et al., 1994) ⁹⁹ and diary information. SB (≤100 vertical cpm), LPA (101–2295 vertical cpm) and MVPA (≥2296 vertical); Trost et al., 2011	No wear time was excluded from the analyses.	Sleep diary
Moreno et al., 2021 ³⁰	Actigraph GT3X-BT on non-dominant wrist;	7 days, except water activities; ≥5 nights and ≥4 days, including 1	Defined by diary.	Sampled at 30 Hz and converted in	Sleep (h/day), SB, LPA and MVPA	Sleep defined by algorithm (Sadeh et al., 1994) ⁹⁹ .	If epochs of low activity existed	Sleep and non-wear time diary.

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
	N.R.	weekend night and day (≥10 waking hours. Nights were considered valid if the participant provided 20 min of wear time before sleep onset.		1-min epoch.	(min/day)	SB, LPA, MVPA cut points were not clear. Actigraph's digital pass filter with a band width of .25 Hz–2.5 Hz, designed to detect normal human behavior.	outside of the scoring interval or if non-wear time occurred during the interval, a consensus was reached by the research team. Non-wear time in the hour before bedtime had to be less than 60 min unless confirmed by the wear log, or unless ambient light data were available to confirm bedtime.	

ID - Authors and year (Country/ study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
Antczak et al., 2021 ³¹	GENEActiv on non-dominant wrist	8 days except in organized contact sports; 4 days, including 1 weekend day (>16h/day)	R-package GGIR detects non-wear time	Sampled at 87.5 Hz and converted into 5-second by R-package GGIR	Sleep, SB, LPA, MPA, VPA, MVPA (min/day)	Sleep (duration) defined by algorithm (Hees et al., 2015) ¹⁰⁴ . SB (ENMOZ 0–56.3 mg), LPA (ENMOZ 56.3–191.6 mg), MPA (ENMOZ 191.6–695.8 mg) and VPA (ENMOZ >695.8 mg); Hildebrand et al., 2014 ¹⁰⁷ and 2017 ¹⁰⁸	No wear time was excluded from the analyses.	No
García-Alonso et al., 2022 ³²	GENEActiv on non-dominant wrist; GENEActiv PC Software	6 days; ≥ 6 days (≥600 min/ day in waking time and an average sleep time ≥ 200 min)	N.R.	Sampled at 87.5 Hz	Sleep (h/day), SB, LPA, MVPA and TPA (min/day)	Sleep defined by algorithm (Hees et al., 2015) ¹⁰⁴ . SB (<56.3 mg); LPA (56.3– 191.5 mg), MPA (191.6–695.7 mg) and VPA (≥ 695.8 mg); Hildebrand et al., 2014 ¹⁰⁷ and 2017 ¹⁰⁸ .	No wear time was excluded from the analyses.	Sleep diary
Hedayatrad et al. 2022 ³³	Axivity AX3 on dominant thigh and lower back; Open Movement Software	7 days; 1 day (24h of concurrent wear time for both sensors)	Detected using the in-built temperature sensor. Schneller et al. 2017 ¹²⁵	5-s epoch; Sampled at 100 Hz converted into counts.	Sleep, SB, LPA, and MVPA (min/day)	Sleep defined by algorithm (Tudor-Locke et al. 2014) ¹⁰⁶ . SB (N.R.); LPA (N.R.), MVPA (N.R); Evenson et al.2008 ¹¹⁷	No wear time was excluded from the analyses.	N.R.
Lucas-de la Cruz et al. 2018 ³⁴	ActiGraph GMTI on right hip for PA, and on wrist for Sleep;	7 days except in water activities; ≥4 days including 1	≥10 min with zero counts	30 Hz converted into 60-s	Sleep, SB, LPA, MPA, and VPA	Sleep (duration) defined by algorithm (Sadeh et al. 1994) ⁹⁹ .	No wear time was excluded from the	Sleep log

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
	KineSoft software	weekend day (≥10 waking h/day).		epoch	(min/day)	SB (0-100 cpm), LPA (101–2295 cpm), MPA (2296–4011 cpm) and VPA (≥4012 cpm); Evenson et al. 2008 ¹¹⁷	analyses.	
Martinez et al. 2019 ³⁵	Actical on right hip; N.R.	3 days - two weekdays, one weekend day (24h/day) except in water activities	≥10 min with zero counts during waking time	60-s epoch	Sleep, SB, LPA, MPA, and VPA (min/day)	Sleep defined as the point when the cpm data changed to consecutive zeros lasting about 8-10 hours, and cross-checked with the participants' wear log for "off" times. SB (AEE <0.01 kcal/kg/min), LPA (AEE 0.01 < 0.04 kcal/kg/min), MPA (AEE 0.04 < 0.10 kcal/kg/min), and VPA (>0.10 kcal/kg/min); Puyau et al. 2004 ¹²⁶	No wear time was excluded from the analyses.	Sleep and non-wear time log
Adolescents (10-17)								
Caetano et al. 2021 ³⁶	ActiGraph GT3X on right hip; ActiLife	8 days except in water activities; 5 days including 1 weekend day (≥10 waking h/day).	Zero consecutive counts/min for at least 20-min.	Sampled at 30 Hz with a standard filter and the data was reintegrated into 15-s epochs.	Sleep (h/day) SB, LPA, MPA, VPA, MVPA (min/day)	Sleep (sleep duration: evaluation of daily charts and inclinometer data, which were crossed with diary data) SB (0-180 cp15s), LPA (181-756 cp15s), MPA (757- 1111 cp15s) and VPA (≥1112 cp15s); Romanzini et al. 2014 ¹²⁷	No wear time was excluded from the analyses.	Movement behaviours diary

ID - Authors and year (Country/ study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
Chong et al. 2021 ³⁷	GENEActiv on non-dominant wrist; GENEActiv PC	6 days; ≥3 days including 1 weekend day (≥16 h/day)	Non-wear time was estimated based on the standard deviation and value range of each accelerometer axis, calculated over 60 min windows with 15 min increments	At 75 Hz and converted in 5-s epoch	Sleep, SB, LPA, MVPA (min/day and % of 24h)	Sleep (Sleep duration) defined by the algorithm (Hees et al., 2018) ¹²¹. SB (ENMO < 52 mg); LPA (ENMO 52–191 mg); MVPA (ENMO ≥ 192 mg); ENMO values were averaged over 5 s epochs, Hildebrand et al., 2014¹⁰⁷	For each 15 min period detected as non-wear time over the valid wearing days, missing data were imputed using the mean values calculated from valid data at the same time points on other days. Any days with ≤200 min of sleep duration or ≤1000 min of ST were considered invalid and were excluded from the analysis	No use
Costa et al., 2020 ³⁸	ActiGraph GT3x+ on non-dominant wrist;	7 days except in water activities; ≥ 3 weekdays and ≥1 weekend	Identified using an algorithm that inspects blocks of 15 min in windows	Sampled at 30 Hz and data were analyzed in	Sleep, SB, LPA, MVPA (min/day).	Sleep (Sleep duration) defined by the algorithm (Hees et al., 2018) ¹²¹ .	No wear time was excluded from the	No use.

ID - Authors and year (Country/ study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
	Actilife.	day (≥ 16 h/day).	of 60 min, classifying each block as non-wear if the standard deviation of the moving averaged 60-min window is less than 13 mg and the value range of the 60-min window acceleration was less than 50 mg for at least two of the three acceleration axes.	5 s epochs.		SB (< 35.6 mg), LPA (35.6 and 201.4 mg) and MVPA (> 201.4 mg); Hildebrand et al 2014 ¹⁰⁷ and 2017 ¹⁰⁸ .	analyses.	
Dumuid et al., 2021 ³⁹	GENEActiv accelerometer on non-dominant wrist; GENEActiv PC and a MATLAB-based customized software program (Cobra).	8 days; 4 days (≥ 10 waking h/day or ≥ 200 min/day for sleep or ≥ 1000 min/d for SB).	N.R.	Data collected at 50 Hz and converted to 60-s epoch.	Sleep, SB, LPA, MVPA (min/day).	Sleep (Sleep duration) defined by the algorithm (Hees et al., 2015) ¹⁰⁴ . SB (244 g.min), LPA (878 g.min) and MVPA (2175 g.min); Philips et al., 2013 ¹²⁸ .	If the device was removed for "sport", the corresponding period of non-wear was imputed with 50% MVPA, 30% LPA and 20% sedentary time.	Sleep and non-wear time diary.

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Negele et al., 2020 ⁴⁰	ActiGraph GT3X on hip on the side of the dominant hand. At night the accelerometer was moved to the wrist on the non-dominant hand side; ActiLife.	7 days; 3 weekdays and 1 weekend day (≥10 waking h/ day).	N.R.	Sampled at 30 Hz and the measured acceleration s stored at 1 Hz after conversion into proprietary “activity count units” summed over a 1 s epoch. For PA: 1 min epoch was used.	Sleep, SB and LPA (% of day), MVPA (min/day).	Sleep defined by algorithm (Sadeh et al., 1994) ⁹⁹ . SB (<200 cpm), LPA (200 to <3028 cpm), MPA (≥3028 and <4448 cpm), VPA (≥4448); Sasaki et al., 2011 ¹²⁹ .	No wear time was excluded from the analyses.	Sleep and non-wear time diary.
Tye et al; 2020	Actigraph GT3X+ on right hip; Actilife.	7 days, except in water activities; 3 days (10 waking h/day; total wear time or wear time plus imputed physical activity ≥ 20 h; ≥	Identified by diary.	Sampled at 30 Hz, saved in 15-s epochs and collapsed into 1-min epoch.	Sleep, SB, LPA, MVPA (min/day).	Sleep duration, defined by the algorithm (Sadeh et al., 1994) ⁹⁹ . SB (<150 cpm; Kozey-Keadle et al., 2011 ¹³⁰), LPA (150 to 1951 cpm) and MVPA (≥1952 cpm); Freedson et al., 1998 ¹¹⁹ .	Activities that were performed during non-wear time, were also recorded, and then manually imputed (manually	Sleep and non-wear time diary.

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
		2 h of sleep.					imputed data accounted for 0.5% of total wear time).	
Van Dyk et al., 2018 ⁴¹	ActiGraph GT3X-BT on waist and SleepWatch on wrist for Sleep.	5 days; N.R. (≥10 waking h/day).	N.R.	N.R.	Sleep, SB, LPA and MVPA (min/day).	Sleep defined by the algorithm (Sadeh et al., 1994) ⁹⁹ . SB (≤100 cpm), LPA (101-2295 cpm) and MVPA (≥2296 cpm); Trost et al., 2011 ¹³¹ .	No wear time was excluded from the analyses.	Sleep and non-wear time diary.
Fairclough et al., 2021 ⁴¹	ActiGraph GT9X on non-dominant wrist; Actilife.	7 days; ≥3 days (16 h/day).	determined based on the SD and value range of the accelerations at each axis, calculated for 60-minute windows with a 15-minute sliding window. If for at least 2 out of the 3 axes the SD was less than 13 mg or the value range was less than 50 mg, the time window was classified as non-wear (Van Hees et	Sampled at 100 Hz and converted to 1 omnidirectional measure of acceleration (ENMO), that was reduced to 5-s epoch.	Sleep, SB, LPA, MVPA (min/day)	Sleep (sleep duration) was defined by the algorithm (Hees et al., 2018) ¹²¹ . SB/LPA (ENMO 50 mg; (Hurter et al., 2018) ¹³³) and MVPA (ENMO 200 mg; Hildebrand et al., 2014) ¹⁰⁷ .	Participants were excluded if accelerometer post calibration error was >10 mg. Non-wear data were imputed by the average at similar time points on other days of the week.	No use.

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			al., 2013) ¹³² .					
Collings et al., 2015 ⁴²	Actiheart on chest	4 days; 1 day (16 h/day with these hours being roughly equally distributed between the morning (3 am-9 am), noon (9 am-3 pm), afternoon (3 pm-9 pm), and midnight (9 pm-3 am) parts of the day)	combination of prolonged periods of zero acceleration accompanied by non-physiological heart rate data, and data were adjusted to minimize potential diurnal bias during summarization.	30-s epoch.	Sleep, SB, LPA, MPA and VPA (min/day)	Sleep (1) Sleep onset constitutes the beginning of sustained low movement registration accompanied by a steady decline in heart rate, 2) Sleep termination constitutes the commencement of movement after long periods of barren movement, together with an abrupt elevation in heart rate. The accumulated time spent in ≤ 1.5 METs between a designated sleep onset and termination period was deemed to be the sleep duration. This was overlaid on the self-reported sleep habits) SB (≤ 1.5 METs), LPA (1.5 to 4 METs), MPA (1.5 to 4 METs) and VPA (> 7 METs).	No wear time was excluded from the analyses.	adolescents were asked to report the times that they usually went to bed and got up on week and weekend days.
Gába et al., 2020 ⁴³	ActiGraph GT9X Link or wGT3X-BT on non-dominant wrist; Actilife.	7 days, except in water activities; ≥ 4 days, including ≥ 1 weekend day	determined based on the SD and value range of the accelerations at each axis, calculated for 60-	Sampled at 100 Hz and converted in 5-s epoch.	Sleep, SB, LPA, MVPA (min/day)	Sleep (the difference between the sleep onset and waking time) was defined by the algorithm (Hees et al., 2015) ¹⁰⁴ .	The data missing due to non-wear time or abnormally high acceleration	Sleep and non-wear time diary.

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
		(≥ 16h/day).	minute windows with a 15-minute sliding window. If for at least 2 out of the 3 axes the SD was less than 13 mg or the value range was less than 50 mg, the time window was classified as non-wear (Van Hees et al., 2013) ¹³² .			SB (ENMO < 36mg), LPA (ENMO 36–200mg) and MVPA (ENMO ≥201mg); Hildbrand et al., 2014 ¹⁰⁷ and 2017 ¹¹⁹ .	values (0.7% of accelerometer data) were imputed using the accelerometer data from the same time interval on the remaining days of the week.	
Kim et al., 2020 ⁵⁵	ActiGraph GT9X on non-dominant wrist; ActiLife	3 days except in water activities; N.R. (≥13 waking h/day)	Choi's algorithm ¹³⁴ in addition to the non-wear time diary	5-s epoch.	Sleep, SB, LPA, MVPA (min/day)	Sleep (Total sleep time) defined by the algorithm (Sadeh et al., 1994) ⁹⁹ . SB (<305 cp15s), LPA (306–817 cp15s), MPA (818–1968 cp15s), VPA (≥1969 cp15s); Chandler et al., 2016 ¹³⁵ ,	No wear time was excluded from the analyses.	Non-wear time diary
Talarico et al., 2018 ⁴⁴	Actical on right hip; imported into SAS statistical software and	7 days; ≥ 4 days (≥ 10 waking h/day).	≥60 consecutive minutes of zero counts, with allowance of 2 min of counts between 0	15-s epoch.	Sleep, SB, LPA and MVPA (min/day)	Sleep (Sleep duration: manually verified, and corrected as necessary, by visually inspecting).	No wear time was excluded from the analyses.	Activity and sleep diary.

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
	processed using a specially designed program.		and 100.			SB (< 100 cpm), LPA (100–1499 cpm) and MVPA (> 1499 cpm); Payau et al., 2002 ¹³⁶ .		
Starbek et al., 2022 ⁴⁵	ActivPAL4 micro on anterior aspect of the right thigh; PAL analysis	14 days; 6 days (20 h/day).	Defined by diary.	Sampled at 20 Hz.	Sleep, SB, LPA and MVPA (min/day).	Sleep (naps and nighttime duration) was defined by summing activPAL4 output called “primary lying time” (That was set based on entered hours of self-reported SL time) and self-reported napping time. SB defined by summing activPAL4 output “sitting time” and “secondary lying time”, while deducting self-reported napping time. LPA defined by residual time to wear time (LPA = 24 h—SL—SB—MVPA—non-wear time). MVPA (100 steps per minute).	If non-wear time existed, the data on lecture/leisure movement behaviours were proportionally rescaled to fit a specific time period.	Sleep and non-wear time diary.

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
						CREA algorithm		
Grant et al. 2020 ⁴⁶	Actical on wrist; Actical software	7 consecutive days including sleep- and water-based activities; N.R. (N.R.)	Remotion of the accelerometer	60-s epochs	Sleep, SB, LPA, MPA and VPA (min/day)	N.R.	Those with a wearing time <168/h were excluded from analysis	Sleep diary
Beltran-Valls et al., 2021 ⁵⁰	GENEActiv, on wrist; GENEActiv Post-Processing PC Software.	N.R.; ≥4 days, including weekends and weekdays (24h/day).	Detected by body temperature sensor.	Sampled at 100 Hz, and converted in 1-s epoch, and data were stored in gravity (g) units (1 g=9.81 m/s ²).	Sleep (hours/day), SB and VPA (min/day).	Sleep defined by algorithm with support of body temperature and luminosity sensors of GENEActiv Post-Processing PC Software. SB (<7 g), VPA (>60 g.); Phillips et al., 2012 ¹²⁸ .	No wear time was excluded from the analyses.	Sleep and non-wear time diary.

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Domingues et al., 2022 ⁵¹	ActiGraph GT3X on right hip; Actilife.	8 days except in water activities; ≥ 4 days (10h/day) and ≥ 3 nights (≥ 160 minutes).	At least 20 consecutive minutes of zero counts/minute recording ¹¹³ .	Sampled at 30 Hz converted in 1-min epoch.	Sleep, SB, LPA, MVPA (min/day)	Sleep was defined by algorithm (Sadeh et al., 1994) ⁹⁹ . SB (≤ 180 cp15s), LPA ≤ 757 cp15s) and MVPA (≤ 1112 cp15s); Romanzini et al., 2014 ¹²⁷ .	No wear time was excluded from the analyses.	No
Harrington et al., 2021 ⁵²	GENEActiv; on non-dominant wrist; GENEActiv software	7 days; N.R. (≥ 16 h/day and < 6 hours or > 12 hours of sleep)	Based on the SD and value range of each axis, calculated for 60-min windows with 15-min moving increments. If, for at least two out of the three axes, the SD is less than 13 mg or the value range is less than 50 mg. Hees et al., 2013 ¹³²	Sampled at 100 Hz and converted in 5-s epoch	Sleep (h/day), SB, LPA, MVPA (min/day)	Sleep defined by algorithm (Hees et al., 2018) ¹²¹ . SB (0–40 mg (minus sleep)); LPA (41–199 mg); MVPA (≥ 200 mg); Hildebrand et al., 2014 ¹⁰⁷ and 2017 ¹⁰⁸	Files were excluded from all analyses if post-calibration error was greater than 0.02 g or if less than 16 hours of wear time was recorded by either monitor during the 24-hour day of interest. if the sleep duration recorded for a night was < 6 hours or > 12 hours and if visual	No

ID - Authors and year (Country/ study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
							examination suggested non-wear or erroneous data.	
Aguilar-Farias et al., 2020 ⁵³	ActiGraph GT3X+ on right hip; ActiLife	7 days except in water activities; ≥ 4 days including a weekend day (≥ 10 waking h/d)	60 consecutive minutes of zero activity counts.	N.R.	Sleep, SB, LPA, MPA, VPA, MVPA (min/day)	Sleep defined by an automated filter (Barreira et al., 2015) ¹²⁴ Vertical (uniaxial) axis cut-points: SB (0-25 cp15s), LPA (26–573 cp15s). MPA (574–1002 cp15s) and VPA (≥1003 cp15s); Evenson et al., 2008 ¹¹⁷	No wear time was excluded from the analyses.	No
Butte et al., 2007 ⁵⁴	Actiwatch on right hip; N.R.	3 days except during water activities; N.R. (≥ 1000 min/day).	If continuous zeros for more than 20 min during awake periods were not accounted for in the subjects log.	1-min epoch.	Sleep, SB, LPA, MPA, VPA, MVPA (min/day).	Sleep manually screened. SB (< 1.5 PAR), LPA (1.5 - 2.9 PAR), MPA (3.0-6.0 PAR) and VPA (> 6.0); Puyau et al., 2004 ¹²⁶ .	No wear time was excluded from the analyses.	Sleep and non-wear time diary.

ID - Authors and year (Country/ study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
Krietsch et al. 2022 ⁴⁷	ActiGraph wGT3x-BT on dominant hip for PA, and SleepWatch on non-dominant wrist for Sleep; ActiLife.	7 days (except water-based activities); ≥3 days (≥10 waking/hr day)	Manufacturer's algorithm and visually verified by condition-blind study staff	30-s 1-s epoch for PA; 60-s 1-s epoch for Sleep	Sleep, SB, LPA, and MVPA (min/day).	Sleep (duration) defined by algorithm Meltzer et al. 2012 ¹³⁷ . SB (0-100 cpm), LPA (101-2295 cpm), and MVPA (>2295 cpm) Trost et al. 2011 ¹³¹	No wear time was excluded from the analyses.	Sleep and non-wear time diary
Master et al. 2017 ⁴⁸	Actigraph GT3X on hip for PA, and Actiwatch on non-dominant wrist for Sleep; ActiLife and R for PA; Philips Actiware software for Sleep	7 days (except water-based activities); ≥3 days (≥10 waking/hr day)	≥ 90 min of consecutive zero counts	Sampled at 80 Hz and converted in 1-s epoch	Sleep, SB, and MVPA (min/day).	Sleep defined by algorithm (Van Hees et al. 2018) ¹²¹ . SB (<1.5 MET) and MVPA (≥3.8 MET) Trost et al. 2012 ¹³⁸	No wear time was excluded from the analyses.	No
Merikanto et al. 2020 ⁴⁹	Actiwatch on non-dominant wrist; N.R.	7 days (except water-based activities); ≥3 days (≥10 waking/hr day)	N.R.	60-s epoch	Sleep, SB, and MVPA (min/day)	Sleep (duration) SB (0-320 cpm), LPA (321-1047 cpm), and MVPA (≥1048 cpm) Ekblom et al. 2012 ¹¹⁵	No wear time was excluded from the analyses.	Sleep log

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
Adults and older adults (≥ 18 years)								
Ataka et al. 2022 ⁵⁶	Silme TM on wrist; N.R.	7 days except in water activities; at least three days including 1 weekend day (at least three hours).	The time when heart rate counts were zero.	1-min epoch.	Sleep duration, SB, LPA, MVPA (min/day).	Sleep (number of minutes asleep between sleep onset and sleep offset: with no movement for more than 20 min; was measured between 6:00 pm and 5:59 am and corrected visually). SB (≤1.5 METs), LPA (1.5–3.0 METs), MVPA (≥3 METs); algorithms developed by the product designer.	No wear time was excluded from the analyses.	No
Betson et al. 2022 ⁵⁷	Actigraph GT9X Link on non-dominant wrist; Actilife	25 days except in water activities; N.R. (N.R.)	N.R.	1-min epoch	Sleep (hours/day) SB and MVPA (time %), and number of steps per day	Sleep defined by the algorithm (Cole-Kripke et al., 1992) ¹²⁰ SB (<100 cpm); LPA (≤ 1951 cpm); MVPA (≥1952); Freedson et al 1998 ¹¹⁹	No wear time was excluded from the analyses.	Sleep log
Blodgett et al. 2022 ⁵⁸	ActivPAL3 on Midline anterior aspect of the upper thigh; participants were requested not to reattach it; activPAL software	7 days; 1 day (10 h of waking wear time)	No non-wear time.	Sampled at the default frequency of 20 Hz.	Sleep duration, SB, LPA, MVPA (min/day)	Sleep defined by algorithm (Winkler et al., 2016) ¹³⁹ . SB (0 steps), LPA (<100 steps/min), MVPA ≥100 steps/min; Hamer et al., 2020 ¹⁴⁰	Non-compliant participants were excluded from the analyses.	Sleep diary

ID - Authors and year (Country/ study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
Booth et al. 2012 ⁵⁹	Actiwatch-64 with an event marker on non-dominant wrist and the Actical on waist; Actiware Sleep version and Actical	14 days except in water activities; Actiwatch for at least 7 nights and the Actical for at least 6 valid days including 1 weekend day (at least 23 h of recorded data)	N.R.	1-min epochs	Sleep, SB, LPA, MPA, VPA and MVPA (min/day)	Sleep (Participants were asked to press the event-marking button each night before going to sleep and again when they got out of bed each morning and the data were crossed with sleep log) SB (subtracted the habitual sleep time from the 24-hour sedentary time of each participant to calculate the amount of habitual sedentary time when he or she was awake.) LPA (<3.0 METs), MPA (≥3 to <6.0 METs), VPA (≥6.0 METs); (Heil, 2006)¹⁴¹	Non-compliant participants were excluded from the analyses.	Sleep logs
Buman et al. 2016 ⁶⁰	GENEActiv on wrist; Activinsights software package	3 days; N.R (N.R.)	Periods of non-wear were screened for and removed based upon variability in the monitor temperature outputs and visual inspection	Initially sampled at 40 hz and summarized to 60 s epochs	N.R.	N.R.	Non-compliant participants were excluded from the analyses.	Movement behaviour digital diary

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
Cabanas-Sánchez et al. 2019 ⁶¹	ActiGraph GT9X on non-dominant wrist; ActiLife software.	7 days except in water activities; ≥4 days including 1 weekend day (at least 16 h/day).	Non-wear time was detected so that each 15-minute block was classified as non-wear time when the standard deviation of 2 out of the 3 axes was lower than 13 mg during the surrounding 1-hour moving window or the value range in 2 of the 3 axes was lower than 50 mg.	Sampled at 100 Hz.	Sleep and SB (h/day). LPA and MVPA (min/day).	Sleep (sleep onset and offset) defined by the algorithm (Hees et al. 2018) ¹²¹ . SB (ENMO <45 mg); LPA (ENMO ≥45 mg and <100 mg); MVPA (ENMO ≥100 mg); ENMO values were averaged over 5 s epochs, Hildebrand et al., 2017) ¹⁰⁸ .	Abnormal high accelerations and non-wear time were imputed by the mean of the acceleration maintained during the same time intervals as the affected periods for the rest of the recording period in each participant.	No use.
Carneiro-Barrera et al. 2020 ⁶²	ActiGraph GT3X+ on non-dominant wrist; ActiLife.	7 days, except in water activities; ≥ 4 days, including 1 weekend day (16 h/day).	N.R.	Sampled at 100 Hz and converted to 1 s epoch.	Sleep, SB, LPA, MVPA, TPA (min/day).	Sleep (total sleep time: total amount of time spent in bed excluding sleep latency) defined by algorithm (Hees et al 2015) ¹⁰⁴ . SB (ENMO < 52 mg); LPA (ENMO 52–191 mg); MVPA (ENMO ≥ 192 mg); ENMO values were	Non-compliant participants were excluded from the analyses.	Sleep and non-wear time diary

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
						averaged over 5 s epochs, Hildebrand et al., 2014 ¹⁰⁷ .		
Dumuid et al., 2018 ⁶³	ActiGraph GT3X+ on waist; Actilife.	7 days, except in water activities; ≥ 3 weekdays and ≥1 weekend days (600 min/day of waking wear).	Periods of 60 minutes of consecutive zero counts.	1-min epoch.	Sleep, SB, LPA and MVPA (min day and % of 24h).	Sleep (Sleep duration: each full day of accelerometer data was then visually inspected by a researcher to determine any discrepancies between self-reported sleep and movement recorded by the device. Where there was discrepancy between the reported times and the trace, the researcher manually identified the bed and wake times using the trace). SB (0-99 cpm), LPA (100-1951 cpm), MPA (1952-5274 cpm) and VPA (≥5275 cpm); Freedson et al., 1998¹¹⁹.	Non-compliant participants were excluded from the analyses.	Sleep and non-wear times diary.
Ellingson et al., 2018 ⁶⁴	SenseWear Mini Armband on the upper arm (sensors for heat flux, galvanic skin response, and skin	10 days, except in water activities; 7 days, including 2 weekend days (≥21 h/day).	Directly measure non-wear time.	1-min epoch.	Sleep and SB (h/day). PA (steps/day).	Sleep (total nighttime sleep derived from minute-by-minute sleep epoch). SB (≤1.5 METs), PA (Average daily steps).	Non-compliant participants were excluded from the analyses.	No use.

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
	temperature); Brand software.							
Full et al., 2020 ⁶⁵	Actigraph GT3X+ on hip; ActiLife.	N.R.; N.R. (≥16H/day), including the primary sleep period to be considered valid.	N.R.	30 Hz. Converted in 1-min epoch for sleep and in 15-s epoch for SB and PA.	Sleep, SB, LPA, MVPA (min/day).	Sleep defined by algorithm (Cole-Kripke et al., 1992) ¹²⁰ . SB (<19 cp15s); LPA (19–518 cp15s) and MVPA (≥519 cp15s); Evenson et al., 2015 ¹⁴² Minutes of in bedtime not classified as sleep by the Cole-Kripke sleep-wake algorithm were classified as minutes of SB, with the low frequency extension filter	Non-compliant participants were excluded from the analyses.	Sleep logs.
Liao et al., 2020 ⁶⁶	Fitbit on wrist; Fitabase.	N.R.; N.R. (≥10 h/day).	Greater than 60 consecutive minutes of 0 steps, with 2 min tolerance (i.e., for 2 min with nonzero counts during non-wear intervals).	1 min-epoch.	“Minutes asleep” for each sleep episode and “Total minutes asleep” within a day. Daily total step counts, “Very active minutes”, “Fairly active	Valid sleep data were defined as having non-nap sleep duration >3 hr. Nap is a sleep episode with a start time between 8 am to 5 pm. Sleep duration was computed by subtracting total nap minutes from “total minutes asleep.”. Sedentary minutes variable was computed by subtracting the active and light activity minutes from the	Non-compliant participants were excluded from the analyses.	No use.

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
					minutes”, and “Lightly active minutes”.	total valid wear time. Active minutes variable was the sum of the “very active” and “fairly active” minutes.		
Millard et al., 2021 ⁶⁷	Axivity AX 3 on non-dominant wrist; N.R.	7 days; N.R. (24 h/day).	The UK Biobank accelerometer analysis tool defined the non-wear time (as consecutive stationary episodes (where all 3 axes had a standard deviation of less than 13.0 Milligravities) lasting for at least 60 minutes.	100 Hz (dynamic range +/- 8 g). The UK Biobank accelerometer analysis tool derives summary activity variables for each 1-minute epoch.	Sleep, SB, LPA, and MVPA (min/day).	Sleep, SB, LPA, and MVPA were defined by a machine learning model (Doherty et al., 2018) ¹⁴³ . MVPA was identified as minutes ≥ 100 mg and then the machine learning model was used to identify min of sleep and SB. All other minutes were considered LPA.	Find all periods of accelerometer data on other days that are during the same time period and have no missing data and impute it.	No use.
Mochón-Benguigui et al., 2021 ⁶⁸	ActiGraph GT3X + on non-dominant wrist; ActiLife.	7 days, except water activities; 4 days, including 1 weekend day (≥ 16 h/day).	N.R.	Sampled at 100 Hz and converted to 1 s epoch.	N.R.	Total sleep time (total amount of time spent in bed minus sleep onset latency). SB, LPA, MPA, VPA and MVPA	Non-compliant participants were excluded from the analyses.	Sleep and non-wear time diary.

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
						cutoffs were not clarified.		
Park et al., 2022 ⁶⁹	ActiGraph GT3X on dominant hip for SB and PA and ActiGraph GT9X on non-dominant wrist for sleep; ActiLife.	7 days; 4 days (10 h/day).	Cho's algorithm ¹³⁴ to the hip accelerometer data to identify non-wear time, after sleep periods be marked as wear time.	Sampled at 100 Hz, converted in 1-min epoch.	Sleep, SB, LPA, MVPA (min/day)	Sleep duration defined by algorithm (Cole-Kripke et al., 1992) ¹²⁰ . SB (≤ 100 cpm), LPA (101–1951 cpm) and MVPA (≥ 1952 cpm); Freedson et al., 1998 ¹¹⁹ .	Non-compliant participants were excluded from the analyses.	Sleep and non-wear time diary.
Park et al., 2021 ¹⁴⁴	SenseWear Mini Armband on the back of upper arm (sensors for heat flux, galvanic skin response, and skin temperature); Brand software.	1 days, except in water activities (24h).	Directly measured.	1 min-epoch.	Sleep, SB, LPA, MPA, VPA and MVPA (min/day).	Behaviours were detected by using proprietary pattern recognition algorithms that are refined over time, based on: SB (≤ 1.5 METs) and MVPA (≥ 3.0 METs).	Non-compliant participants were excluded from the analyses.	Log to record the duration and types of activities performed while the SWA was not worn.
Suorsa et al., 2022 ⁷⁰	ActiGraph GT3X-BT for SB and PA and ActiSleep-BT for sleep on non-dominant wrist; ActiLife.	7 days; 4 days (≥ 10 waking h/day, and no specific restrictions were made regarding night duration).	15 min time blocks based on the characteristics of the 60 min time window centered at these 15 min. A block was classified as non-wear time if	Sampled at 80 Hz.	Sleep, SB, LPA, MVPA (proportion of the 24-h day).	Sleep duration, defined by the algorithm and logs (Hees et al., 2015) ¹⁰⁴ . SB (< 30 mg), LPA (30 to 100.6 mg) and MVPA (≥ 100.6 mg); Hildebrand	Data excluded if < 4 days and < 10 waking h/day.	Daily log (record the date, waking time, bedtime and working times)

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			the standard deviation of the 60 min window was less than 13.0 mg (milli gravity-based acceleration unit, where 1 g = 9.81 m/s ²) for at least two out of the three axes or if the value range, for at least two out of three axes, was less than 50 mg.			et al., 2014 ¹⁰⁷ .		
Curtis et al., 2020 ⁷¹	GENEActiv on left wrist; N.R.	7 days, except in water activities; 4 days, including a minimum of 1 weekend day (≥10 waking hours).	Periods of 60 minutes of less than 25 counts per minute were considered nonwear time and excluded from the analysis.	Sampled at 50 Hz, converted in 1-min epoch.	Sleep, SB, LPA, MVPA (min/day; % of time).	Sleep (sleep and wake times were manually identified on the accelerometer trace). SB (<188 cpm), LPA (188 cpm), MPA (403 cpm), VPA (1131 cpm); Eslinger et al., 2011 ¹⁴⁵ . If behaviors did not sum to 24 hours, small linear adjustments were made to the daily mean durations so that 100% was equivalent to 24 h for	Non-compliant participants were excluded from the analyses.	Sleep and non-wear time diary.

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
						every participant.		
Cabanas-Sanchez et al., 2018 ⁷²	IDEAA pattern-recognition activity monitor on waist (Three sensors, connected to the main recorder device by wires, were attached to the anterior sternum and the anterior side of each thigh. Moreover, two sensors were placed on the plantar surface under each foot; these sensors are connected by wires to two subrecorders located on the lateral side of each ankle which, in turn, are wirelessly	2 days, except in water activities; ≥ 1 day (≥ 10 waking h/day and with the sleep period detected).	N.R.	Sampled at 32 Hz.	Sleep, SB, LPA, MVPA (% of time; h/day).	Sleep (Sleep period: the time while lying, reclining, or sitting during the sleep period) defined by algorithm (Cabanas-Sanchez et al., 2018) ¹⁴⁶. Lying, reclining, passive sitting, active sitting, standing, walking, and other activities; Cut points were not clear. Walking was divided into two categories according to the 2.5-mph cut point, which identifies light (<2.5 mph) and moderate-to-vigorous (≥ 2.5 mph) intensities.	Non-compliant participants were excluded from the analyses.	No use.

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	connected to the main recorder device).							
Husu et al., 2021 ⁷³	UKK RM42 on right hip for PA and on non-dominant wrist for sleep	7 days, except in water activities; ≥4 days (24h)	> 120 min in quiescent time	Sampled at 100 Hz and converted in 6-s epoch	Sleep, SB, standing (h/day), LPA, MPA, VPA (min/day)	SB and standing (MAD < 22.5) LPA (≥ 1.5 and <3.0 (MAD = 22.5 and 91.5 mg)); MVPA (≥ 3.0 (MAD > 91.5 mg)); Vähä-Ypyä et al., 2015	Non-compliant participants were excluded from the analyses.	Sleep diary.
Knaeps et al., 2017 ⁷⁴	SenseWear Pro 3 Armband on arm; SenseWear Professional software	7 days, except in water activities; 3 weekdays and 2 weekend days (≥ 1296 minutes)	N.R.	N.R.	Sleep, SB, LPA, MVPA (min/day).	Sleep time was defined by algorithms developed by the manufacturer (Shin et al., 2015) ¹⁴⁷ SB (≤ 1.5 MET), LPA (1.5 – 3 MET) and MVPA (>3 MET); (Shin et al., 2015) ¹⁴⁷ .	Non-compliant participants were excluded from the analyses.	No use
Mitchell et al., 2016 ⁷⁵	ActiGraph GT3X+ on waist (just waking hours) and on non-dominant wrist (24h); Actilife	7 days, except in water activities; 1 day (the hip acc: ≥ 10 waking hours; Wrist acc: no information)	Choi et al. ¹³⁴ algorithm to the hip accelerometer data to identify non-wear time.	N.R.	Sleep and SB (h/day), MVPA (h/day).	Sleep (Total sleep time) defined by algorithm (Cole–Kripke et al., 1992) ¹²⁰ . SB (<100 cpm), MVPA (>1040 cpm); Copeland et al., 2009 ¹⁴⁸ and Matthews et al., 2008 ¹⁴⁹	Non-compliant participants were excluded from the analyses.	Sleep and non-wear time diary
Powell et al.,	ActiviPAL3	7 days, except in water	period of ≥ 60 min of consecutive zero	Sampled at	Sleep, SB, standing time,	Sleep (The last registered non-sedentary epoch of the day, which	Non-compliant participants	Wear time

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2020 ⁷⁶	Micro on right thigh	activities; ≥ 4 days, including ≥1 weekday and ≥1 weekend day (≥ 10 waking h/day)	counts	20 Hz	LPA, MVPA (% of 24h in min/day)	was followed by a long uninterrupted sedentary period (> 2 h), was identified as sleep) SB and standing time (calculated using the postural function of the monitor, through the proprietary software). LPA (24h - (SB + standing time + MVPA) MVPA (≥ 5123 cp15s); Powell et al., 2017 ¹⁵⁰	were excluded from the analyses.	diary
Gupta et al., 2020 ⁷⁷	ActiGraph GT3X+ on thigh; Actilife and MATLAB program Acti4	5 days; 1 day (≥4 h of work and leisure and ≥4 of sleep)	(a) periods longer than 60 min showing zero counts per minute, (b) workers reported non-wear periods in the diary and (c) detection of artefacts or missing	N.R.	Sleep, SB, LPA, MVPA (min/day)	Sleep (time spent in bed) was visually checked and crossed with diaries. Sitting and/or lying and standing and walking slow (SB and LPA; <100 steps per min) and running, cycling and stair climbing (MVPA; >100 steps per min); Skotte et al., 2014 ¹⁵¹	Non-compliant participants were excluded from the analyses.	time of starting and ending work and going to and out of the bed each day, time of reference measurement, and nonwear

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			data via visual inspection of the accelerometer data.					
Verhoog et al., 2020 ⁷⁸	GeneActiv on non-dominant wrist; PAMPRO processed in Python.	7 days; ≥4 days (>1,200 min/day).	Time periods where the SD of acceleration in all 3 axes fell below 13 mg for >1 hour and was excluded from analyses.	Sampled at 50 Hz.	Sleep, SB, LPA, MVPA (min/day).	Sleep (Sleep duration) defined by algorithm (Hees et al., 2015) ¹⁰⁴ . SB (<48 mg), LPA (48–154 mg) and MVPA (>154 mg); White et al., 2016	Non-compliant participants were excluded from the analyses.	Sleep diary.
Full et al., 2019 ⁷⁹	Actigraph GT3X+, on the hip (not specified, just waking hours) for PA and on the wrist (not specified, 24h) for sleep; Software N.R.	7 days; ≥5 days (≥10 waking h/day)	90 consecutives minutes of zero counts	N.R.	Sleep, SB, and MVPA (min/day)	Sleep (duration) defined by algorithm (Cole-Kripke et al., 1992) ¹²⁰ . SB (0–99 cpm), MVPA (≥2020 cpm), Troiano et al. 2008 ¹⁵²	Non-compliant participants were excluded from the analyses.	Sleep diary
Galmes-Panades et al. 2019 ⁸⁰	GENEActiv tri-axial on non-dominant wrist; GGIR package in R	7 days; ≥3 days (≥10 waking h/day)	N.R.	Sampled at 40 Hz	Sleep, SB, LPA, and MVPA (min/day)	Sleep (Nighttime sleep duration) defined by the algorithm (van Hees et al 2018.) ¹²¹ SB (<40 mg), LPA (48 < 100 mg), and	Non-compliant participants were excluded from the analyses.	Sleep diary

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
						MVPA (≥ 100 mg). Rowlands et al. 2018 ¹⁵³		
German et al. 2020 ⁸¹	Actiwatch Spectrum on non-dominant wrist; Actiware-Sleep v.5.59 software	7 days; ≥ 3 days (≥ 10 waking h/day)	N.R.	30-s epochs	Sleep, SB, LPA, and MVPA (min/day)	Sleep (Nighttime sleep duration) defined by the algorithm (Oakley 1997) ¹⁵⁴ . SB (< 178.5 cpm), LPA (178.6–562.4 cpm), and MVPA (> 562.4 cpm). Landry et al. 2015 ¹⁵⁵ .	Participants without 600 daily minutes of wear time on at least 3 days were excluded from analyses	Sleep diary
Gilson et al. 2021 ⁸²	ActiGraph GT3X on non-dominant wrist; GGIR package in R	7 days; ≥ 4 days (including at least 1 non-working day) (16h/day)	N.R.	5-s epochs	Sleep, SB, LPA, MPA and VPA (min/day)	Sleep (Nighttime sleep duration) defined by the algorithm (van Hees et al. 2018) ¹²¹ . SB (< 30 mg), LPA ($30 < 99$ mg), MPA ($100 < 399$ mg), and VPA (> 400 mg); Hildebrand et al. 2014 ¹⁰⁷	Non-compliant participants were excluded from the analyses.	Sleep diary and working non-working diary
Goncin et al. 2020 ⁸³	ActivPAL on right anterior thigh ActivPAL; Open Movement software	7 days including sleep- and water-based activities; ≥ 3 days (≥ 10 waking h/day)	24-h bouts ≥ 2 h or any bout ≥ 5 h without detectable movement	Sampled at 20 Hz	Sleep, SB, LPA, MPA and VPA (min/day)	Sleep, SB, LPA, MPA and VPA defined by the algorithm (Winkler et al. 2016) ¹³⁹	Non-compliant participants were excluded from the analyses.	N.R.

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
Gubelmann et al. 2018 ⁸⁴	GENEActiv tri-axial on right wrist; GENEActiv software and GGIR package in R	14 days; ≥7 days (5 weekdays and 2 weekend days; ≥10 and ≥8 waking/h day on weekdays and weekend days, respectively)	N.R.	Sampled at 50 Hz collapsed into 60-s epochs	Sleep, SB, LPA, and MVPA (min/day)	Sleep (Nighttime sleep duration) defined by algorithm (Hees et al., 2015) ¹⁰⁴ . SB (<241 g/min), LPA (241–338 g min), and MVPA (>338 g min); Eslinger et al. 2011 ¹⁴⁵	Non-compliant participants were excluded from the analyses.	Sleep quality derived from the questionnaire.
Gupta et al. 2018 ⁸⁵	ActiGraph GT3X on the right thigh; MATLAB (Acti4)	4 consecutive days, including ≥2 working days (≥10 waking/h day)	Defined by diary.	N.R.	Sleep, SB, LPA, and MVPA (min/day)	Sleep (Nighttime sleep ascertained through time in bed). SB, LPA, and MVPA (N.R.).	Non-working days and non-wear periods of accelerometers were excluded	Diary on working hours, time in bed (going to and getting out of bed), and nonwear time
Hargens et al. 2021 ⁸⁶	ActiGraph GT3X on waist for PA and on non-dominant wrist (time in bed) for Sleep; Actilife	7 days (except water-based activities); ≥3 days (≥8 waking/hr day)	Wear time was determined by Choi's algorithm ¹³⁴	Sampled at 30 Hz collapsed into 60-s epochs	Sleep, SB, LPA, MPA, VPA, and VVPA (min/day)	Sleep (duration) defined by algorithm (Sadeh et al. 1994) ⁹⁹ . SB (0-99 cpm), LPA (100–1951 cpm), MPA (1952-5724 cpm), VPA (5725–9498 cpm), and VVPA (>9499 cpm); Freedson et al. 1998 ¹¹⁹	Non-compliant participants were excluded from the analyses.	Sleep log

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
Heiland et al. 2021 ⁸⁷	ActiGraph GT3X on waist for PA and on non-dominant wrist (time in bed) for Sleep; Actilife	8 days (except water-based activities); ≥4 days (≥8 waking/h day)	≥60 min with zero counts	Sampled at 30 Hz collapsed into 60-s epochs	Sleep, SB, and MVPA (min/day)	Sleep (duration) defined by algorithm (Cole –Kripke et al. 1992) ¹²⁰ . SB (0-199 cpm) and MVPA (>2690 cpm). SB - Sasaki et al. 2011 ¹²⁹ MVPA - Aguilar-Farias et al. 2014 ¹⁵⁶	Non-compliant participants were excluded from the analyses.	Sleep log
Imes et al. 2021 ⁸⁸	ActiGraph GT3x on hip for PA and Actiwatch2 on non-dominant hand for sleep; Actilife and Actiware, respectively	7 days (except water-based activities); ≥4 days (≥10 waking/hr day)	N.R.	Sampled in 30 Hz collapsed into 60-s epochs	Sleep, SB, and MVPA (min/day)	Sleep (duration) defined by algorithm (Oakley 1997.). SB (0-199 cpm) and MVPA (>2690 cpm); SB - Sasaki et al. 2011 ¹²⁹ MVPA - Aguilar-Farias et al. 2014 ¹⁵⁶	Non-compliant participants were excluded from the analyses.	Sleep log
Le et al. 2021 ⁸⁹	ActiGraph wGT3X-BT on wrist; ActiLife	2 days, 7 days, and 15 days (except water-based activities; N.R. (N.R.))	≥ 90 min of consecutive zero counts validated by algorithm Choi et al. 2011 ¹³⁴	60-s epochs	Sleep, SB, LPA and MVPA (min/day)	Sleep (duration) defined by algorithm (Cole–Kripke et al., 1992) ¹²⁰ . SB (< 231 cpm), LPA (232–4514 cpm), and MVPA (> 4515 cpm); Lee et al. 2019 ¹⁵⁷	Non-wear time reallocated to other wake components proportionally based on the time they contributed to the total day.	Sleep diary

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
Lee et al. 2020 ⁹⁰	ActiGraph GT1M on dominant hip for PA, and Actiwatch-2 on non-dominant wrist for Sleep; ActiLife	7 days (except water-based activities); ≥4 days (≥10 waking/hr day)	≥ 60 min of consecutive zero counts	60-s epochs	Sleep, SB, LPA, MPA, and VPA (min/day)	Sleep (duration) defined by algorithm (Oakley 1997). SB (<100 cpm), LPA (100–1951 cpm), MPA (1952–5724), and VPA (≥5725 cpm) Freedson et al. 1998 ¹¹⁹	Non-compliant participants were excluded from the analyses.	Sleep diary
Madden et al. 2014 ⁹¹	SensewearPro for PA and Sleep on arm; R core software package	7 days; ≥4 days (≥23 wearing h/day)	N.R.	1-s epochs	Sleep, SB, LPA, and MVPA (min/day)	Sleep (duration) defined by algorithm (not clear). SB (0–99 cpm), LPA (100–1951 cpm), and MVPA (≥1952 cpm) Freedson et al. 1998 ¹¹⁹	Non-compliant participants were excluded from the analyses.	N.R.
McDonough et al. 2022 ⁹²	ActiGraph GT9X+ on non-dominant wrist; ActiLife and R Studio-package GGIR	7 days (except water-based activities); N.R. (N.R.)	N.R.	Sampled in 30Hz collapsed into 5-s epochs	Sleep, SB, LPA, and MVPA (min/day)	Sleep (duration and efficiency) defined by algorithm (Hees et al., 2015) ¹⁰⁴ . SB (0–56.2 mg), LPA (56.3 –191.6 mg), and MVPA (>191.6 mg) Hildebrand et al. 2014 ¹⁰⁷ .	Intent-to-treat using chained equations (R Studio)	Wearing time and Sleep log

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
Meyer et al. 2020 ⁹³	SenseWear armband on the upper arm; N.R.	10 days (except water-based activities); ≥5 days, including 2 weekend days (≥18.5 waking/h day)	N.R.	60-s epoch	Sleep, SB, LPA and MVPA (min/day)	Sleep (duration) defined by algorithm (SenseWear Sleep algorithm). SB (1.0–1.5 METs); LPA (1.6–2.9 METs) MVPA (≥3.0 METS). Reece et 2015 ¹⁵⁸ .	Non-compliant participants were excluded from the analyses.	Activity and Sleep log
Pasanen et al. 2022 ⁹⁴	ActiGraph wGT3X-BT on non-dominant wrist; R-package GGIR	8 days/7 nights (except water-based activities); ≥4 days, including 3 nights (≥10 waking/h day)	≥ 60min of <50 mg 2/3 axes or a SD <13.0 mg	N.R.	Sleep, SB, LPA and MVPA (min/day)	Sleep (duration) defined by algorithm (Van Hees et al. 2015) ¹⁰⁴ . SB (<30.0 mg), LPA (>30.0-100.6 mg), and MVPA (>100.6 mg) Rowlands et al. 2018 ¹⁵³	Non-compliant participants were excluded from the analyses.	Daily log (including sleep)
Seol et al., 2019 ⁹⁵	Omrom Active Style Pro HJA-350IT on left side of their waists for PA and SB and actigraph (model not reported) on non-dominant wrist for sleep;	7 days; N.R (10 waking h except in water activities)	Intervals of at least 60 consecutive minutes of zero counts, and the total wearing time was computed as 24 h minus non-wearing hours	1-min epoch.	Sleep, SB, LPA and MVPA (min/day)	Sleep (duration) defined by algorithm (Cole–Kripke et al., 1992) ¹²⁰ . SB (1.0–1.5 METs); LPA (1.6–2.9 METs) MVPA (≥3.0 METS), were then scored into units of 30 min per day to facilitate interpretation of the results.	Sleep data on days where no activity data were measured by the accelerometer were excluded from the	Sleep diary

ID - Authors and year (Country/ study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
	Actilife						analysis.	
Tigbe et al., 2017 ⁹⁶	ActivPAL on mid anterior thigh; N.R.	7 days except in water activities; 3 24-hour periods, including a weekend day (N.R.)	Defined by diary	N.R.	Sleep, SB, and standing (h/day) Stepping (steps/min).	Sleep (duration) was defined as prolonged periods (>2 hours) of continuous inactivity during sleeping hours (extracted from the activPAL raw output) SB (Sleep duration was subtracted from total sedentary time to obtain waking hours" sedentary time. Stepping and standing (not reported).	Non-compliant participants were excluded from the analyses.	Non wear time diary
Wang et al., 2022 ⁹⁷	ActiGraph GT3X on hip for PA and SB and on the left wrist for sleep	14 days; 8 days (600 min/day of wear time	N.R.	N.R.	Sleep, SB, LPA, MPA, VPA, Very VPA (% of time)	Sleep duration was recorded by the participants from the time that they began trying to fall asleep till the time they got out of bed in a daily diary. SB (<1.5 METs), LPA (1.5–3 METs); MPA (3–6 METs); VPA (6–8.9 METs) Very VPA (9 METs); No ref	Non-compliant participants were excluded from the analyses.	Sleep diary

ID - Authors and year (Country/study)	Acc model, Placement on the body; software used	N° of days for data collection; n° of required valid days (minutes required)	Criteria for non-wear time	Epoch Length and data reduction (epoch integration)	Movement Behaviour outcome and Reporting formats	Sleep measuring procedure and PA and SB cut points	Procedures handling non-compliant participants	Log or diary
Santos et al., 2021 ⁹⁸	Actigraph GT3X + on dominant wrist; Actilife.	7 days, except in water activities; 3 weekdays and 1 weekend day (≥10 waking h/day).	N.R.	Sampled at 100 Hz and processed as 10-s epoch. Sleep was analyzed by 1-min epoch.	Sleep, SB, LPA, MPA, VPA and MVPA (h/day).	Sleep (Total sleep time), defined by the algorithm (Cole–Kripke et al., 1992) ¹²⁰ . SB (0-275 cp5s), LPA (276-415 cp5s), MPA (≥ 778 cp5s) and VPA (≥ 416 cp5s); Crouter et al., 2015 ¹⁵⁹ .	No wear time was excluded from the analyses.	Sleep diary

Legend: h: hours; min: minutes; s: seconds; SB: sedentary behaviour; PA: physical activity; LPA: light physical activity; MPA: moderate physical activity; VPA: vigorous; MVPA: moderate to vigorous physical activity; TPA: total physical activity; cpm: counts per minute; N.R.: not reported; Hz: Hertz; cp15s: counts per 15 seconds; METs: Metabolic equivalents; mg: milligravitational units; ENMO: Euclidean Norm Minus One; g.min: gravity minutes; g: gravity units; HRR: Heart Rate Reserve; cp5s: counts per 5 seconds; HPFVM: high-pass filtered vector magnitude; PAR: Physical activity ratio; MAD: Mean amplitude deviation.

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Chapter 8

- Overall Discussion

8.1. Overall discussion

This thesis was conceived with the general aim of understanding how to accurately assess 24-hour movement behaviours levels and guidelines' compliance, through accelerometers and questionnaires, in large scale scientific projects, clinical settings, and health surveillance systems.

Regarding questionnaires, we began by summarizing the evidence to understand if existing questionnaires could address the new 24-hour movement behaviours paradigm (i.e., assess movement behaviours over 24-hour periods, in an integrated fashion), to then decide whether to adopt or adapt an existing questionnaire, or create a new questionnaire. For this, two systematic reviews of existing validated questionnaires were conducted. The first review (Paper I) included questionnaires for adults and older adults (Rodrigues, Encantado, Carraça, Sousa-Sá, et al., 2022), while the second (Paper II) included questionnaires for children and adolescents (Rodrigues, Encantado, Carraça, Martins, et al., 2022). These systematic reviews analysed content and measurement properties of existing questionnaires, specifically their validity and reliability. In Paper I, we analysed 60 questionnaires, of which 25 measured PA, 12 measured SB, one measured sleep, 12 measured the combination of PA and SB, one measured the combination of SB and sleep, and nine measured the combination of PA, SB, and sleep. In Paper II, we analysed 37 self-reported questionnaires and seven proxy-reported questionnaires. Of these, 20 measured PA, six SB, one sleep duration, eight the combination of PA and SB, and two the combinations of sleep, SB and PA.

Content-wise, both reviews showed that questionnaires varied greatly in terms of assessed domains, response methods, measurement units, scores, recall and assessment periods, which made comparisons difficult and hindered the selection of one questionnaire over another. Also, neither review identified questionnaires that assessed all 24-hour movement behaviours in an integrated fashion.

In both reviews, the validity of the included questionnaires was mostly assessed by comparing them with accelerometers. Although the limitations of accelerometry, this is considered one of the best device-based criterion

measures for assessing movement behaviours (Troiano et al., 2014). This is because accelerometers collect data on the amount and intensity of body (non)movement, continuously over extended periods of time, and in free-living conditions. Moreover, accelerometers are relatively easy to use, posing a low burden for researchers and participants. They have high sensitivity in detecting changes in movement behaviours (Welk, 2002) and can assess all three movement behaviours simultaneously.

Generally, both reviews showed high heterogeneity regarding questionnaires' content, measurement properties and its quality. The quality of validity and reliability results were often considered inadequate. This may be due to desirability bias or cognitive issues related to recall or comprehension of the questionnaires in the case of adults (Sallis & Saelens, 2000), and due to social desirability, language, interpretation, questionnaire's complexity, age, and seasonal variation in the case of children and adolescents (Erwin & Bashore, 2017; Lubans et al., 2011; Sallis & Saelens, 2000; Strath et al., 2013).

In the review of questionnaires for adults and older adults (Paper I), only the Athens Physical Activity Questionnaire (Kavouras et al., 2016), demonstrated an adequate overall quality for criterion validity. However, the validation results were only for total energy expenditure, which requires a cautious interpretation, because this outcome poses some limitations. Total energy expenditure depends on factors other than movement behaviours, such as resting energy expenditure and the thermic effect of food digestion (Strath et al., 2013); ii) accelerometry may not be the most appropriate criterion measure for assessing energy expenditure (Strath et al., 2013); iii) it is not possible to determine energy expenditure for each movement, and finally, energy expenditure is not a time-focused variable.

In the review of questionnaires for children and adolescents (Paper II), none of the questionnaires demonstrated overall 'adequate' criterion validity and only one questionnaire showed adequate convergent validity (Teo et al., 2013).

Regarding reliability, both reviews frequently found the overall quality of results to be inadequate. However, it is important to note that these results are dependent on the number of scores evaluated by the authors. For example,

while the Physical Activity Scale for the Elderly (Washburn et al., 1993) was rated as having 'adequate' reliability, the authors only assessed reliability for a single score. In contrast, more complex questionnaires (i.e., with more scores), such as the Workforce Sitting Questionnaire (Chau et al., 2011), that presented 'adequate' reliability result in a general score (i.e., total, all domains ICC=0.80), the overall quality was considered 'inadequate', due to the separated scores for reliability. In both reviews, a common shortcoming of the questionnaires' validation process was the use of Pearson or Spearman correlations alone. This was not appropriate as these methods do not account for systematic errors. Instead, it would have been more appropriate to combine them with ICCs or Kappas to analyse the test-retest reliability, as ICCs are considered more appropriate (Armitage & Colton, 1998; Streiner et al., 2015). Additionally, for absolute validity and reliability by means and LoA, Bland and Altman plots are recommended (Bland et al., 2012). However, these were only calculated in a limited number of the studies included in both reviews, either to report on validity or reliability.

Although proxy-reported questionnaires have known shortcomings (Pate, 1993), they are often the only feasible method for assessing movement behaviours in children and older adults (Corder et al., 2008; Harro, 1997; Loprinzi & Cardinal, 2011; Telford et al., 2004). Nonetheless, the review on adults and older adults' questionnaires did not found proxy-reported questionnaires; and, the review on children's questionnaires only included seven proxy-reports (Bringolf-Isler et al., 2012; Ching & Dietz, 1995; De Moraes et al., 2020; Nascimento-Ferreira et al., 2018; Telford et al., 2004; Werner et al., 2009) targeting parents or caregivers of children aged 3 to 10 years. None of the studies showed adequate validity and only The Children's Leisure Activities Study Survey - Proxy (Telford et al., 2004) and Children's ChronoType Questionnaire (Werner et al., 2009) presented adequate reliability. Additionally, this review did not include proxy-reports directed at toddlers' parents or caregivers, which is an important gap that needs to be addressed, especially considering the development of 24-hour movement guidelines for young children (Okely et al., 2017; Tremblay, Chaput, et al., 2017; WHO, 2019b).

In both reviews, none of the included questionnaires showed adequate criterion validity and reliability simultaneously. This is a required criterion for questionnaire validation purposes (Prinsen et al., 2018; Terwee et al., 2010). For example, the IPAQ (Craig et al., 2003) presented simultaneously adequate reliability and convergent validity, but not for criterion validity. To achieve adequate validation, a questionnaire must attain at least satisfactory overall validity and reliability, and a criterion measure (when possible) is preferable to a convergent one for this purpose (Prinsen et al., 2018).

The low validity and reliability, and other methodological limitation of movement behaviours questionnaires found in the reviews, have also been reported in previous reviews (Biddle et al., 2011; Chinapaw et al., 2010; Helmerhorst et al., 2012; Hidding et al., 2017; Hidding et al., 2018; Ibáñez et al., 2018; Lubans et al., 2011; Nascimento-Ferreira et al., 2016; van Poppel et al., 2010). This is concerning given that if questionnaires development methods and measurement properties do not follow best practices or are poor, respectively, there is a high risk of misclassification, bias, and inaccurate results (Lagerros, 2009).

In both reviews, the shortcomings of the included questionnaires, highlight the complexity of assessing the full spectrum of movement behaviours over the 24-hour period. Altogether and with the emergence of 24-hour movement guidelines, raises the need to develop new self-reported instruments to assess 24-hour movement behaviours. A similar concern has been raised regarding the new WHO PA and SB guidelines for adults (Troiano et al., 2020). Indeed, the lack of questionnaires assessing 24-hour movement behaviours in an integrated manner, precludes an accurate report of compliance with 24-hour movement behaviour guidelines and trends over time (Lagerros & Lagiou, 2007; WHO, 2019a).

Studies on the combination of 24-hour movement behaviours have shown that most studies do not use adequate analytical methods to account for the compositional nature of time-use data. This can lead to biased results regarding the relationship between movement behaviours and health outcomes (Pedišić, 2014; Pedišić et al., 2017). Furthermore, as new guidelines are being

developed and public health efforts to improve movement behaviours levels continue, there is a need to improve measurement instruments and adapt surveillance systems (Hallal et al., 2012). These will enable researchers, public health professionals and policymakers to push forward the (i) monitoring of 24-hour movement behaviours; (ii) the assessment of compliance with 24-hour movement guidelines; (iv) the analysis of the health-related associations of movement behaviours combinations and (v) the promotion of healthy 24-hour movement behaviours.

After the publication of our systematic reviews, some 24-hour movement behaviours questionnaires have been developed (Kastelic et al., 2022; Phillips et al., 2023; Rahim et al., 2023; Song et al., 2021). The questionnaire published by Philips et al. (2023), is a seven-day daily reported activity diary that was considered comprehensive of children's (3-4 years old) movement behaviours and comprehensible to parents and carers. However, the authors did not perform any analysis of criterion/convergent validity or test-retest reliability (Phillips et al., 2023). The study of Rahim et al. (2023) was a translation (into Malay language), cross-cultural adaptation and content validation of a movement behaviour questionnaire developed by Trost (2022), that was not originally published and validated. The questionnaire developed by Song et al (2021) was developed for South Korean adolescents aged 13-17 years and was considered reliable. However, the authors did not perform convergent/criterion validity. Kastelic et al., (2022) developed and validated a questionnaire to estimate the time spent in sleep, SB, light physical activity, and MVPA among Slovenian adults. The questionnaire is available in Croatian, English, German, and Slovenian languages. The validated version (i.e. Slovenian) produced results that were comparable with existing questionnaires, with the advantage of allowing a comprehensive assessment of all 24-hour movement behaviours (Kastelic et al., 2022). However, they did not perform a qualitative evaluation of the questionnaire's content, and it does not include specific questions for light-intensity PA. In this sense, it seemed that currently the biggest gap at this level would be in adults. Therefore, we decided to develop first a questionnaire for adults and older adults – The 24-hour Movement Questionnaire (QMov24h).

However, the final questionnaire was only validated for use with adults. This decision was made after consulting with experts and end-users, who determined that the questionnaire for older adults should be administered through interviews. A study that will be conducted late 2024 by our research team.

The outcomes of the QMov24h are the time (hours or minutes) spent per day in sleep and LPA; and the frequency (i.e. number of days); and the time (hours or minutes) spent in MPA (aerobic and strength activities), VPA (aerobic and strength activities) and balance activities, with these being able to be averaged by day. Given the continuous nature of the outcomes of the questionnaire, the outcomes can be categorized to assess compliance with 24-hour movement behaviour guidelines, as well as future updates of guidelines. The instruction of the questionnaire provides relevant cues and examples of the behaviours of interest. For instance, to facilitate participants' understanding of which activities were relevant to each question, we provided a definition and multiple examples for each behaviour and intensity, as well as pictograms.

The final version of the questionnaire was developed after meetings with experts and end-users to evaluate content and face validity, where some changes were made to achieve a clearer version of the questionnaire. These qualitative measurement properties are important measurement properties, that are often overlooked. Indeed, few studies evaluate the relevance, comprehensiveness, and comprehensibility of the questionnaire, as our study did (Prinsen et al., 2018; Willis, 2004). In terms of quantitative measurement properties, the QMov24h presented adequate criterion/convergent validity and reliability. The QMov24h demonstrated moderate criterion validity for sleep, light PA and total aerobic PA, and strong criterion validity for SB and aerobic MVPA. The questionnaire also exhibited good agreement with accelerometers measures in all main movement behaviours variables, with SB and LPA being slightly underestimated in the questionnaire, while aerobic MVPA was marginally overestimated by the questionnaire. The QMov24h presented moderate convergent validity for naps and very strong convergent validity for all strength and balance variables. The reliability of the QMov24h varied from good

to excellent in all questionnaire variables. There was good agreement between the first and second administration of the questionnaire for all questionnaire variables, with aerobic MVPA being slightly overestimated on the first administration of the questionnaire. In terms of compliance with the 24-hour movement behaviour guidelines, the questionnaire demonstrated strong to almost perfect agreement (criterion validity) with accelerometry, and minimal to strong reliability between the first and second administrations of the questionnaire.

Regarding sleep variables, the questionnaire presented adequate validity and reliability for sleep variables, which is consistent with the validation results of other questionnaires, that focus solely on sleep. However, direct comparisons should be made with caution as other validations of sleep questionnaires generally focus on the validity of summary scores based on several dimensions of sleep, such as sleep quality, and not specifically on sleep duration or against different criterion methods (Cespedes et al., 2016; Mollaveva et al., 2016). Additionally, while other sleep questionnaires have a tendency to overestimate sleep duration when compared to accelerometry (Cespedes et al., 2016; Lauderdale et al., 2008), the QMov24h showed a good agreement without proportional bias between the two methods.

Regarding SB variables, despite having different methodologies (e.g., accelerometer model, body placement, cut-points, etc.), the total SB variable from the QMov24h ($\rho=0.43$) achieved slightly better validity results when compared with most of the SB questionnaires ($r=0.32$) (Prince et al., 2020). Furthermore, the QMov24h demonstrated higher SB validity results compared to well-established questionnaires, such as the usual week IPAQ long (ρ from 0.14 to 0.22) and short (ρ from 0.07 to 0.26, against accelerometers) forms (Craig et al., 2003), and the GPAQ ($\rho=-0.20$, against pedometers) (Bull et al., 2009). QMov24h showed good agreement with a slight underestimation of the questionnaire (-1.01 ± 1.92 hours per day). This finding is similar to some studies (Chau et al., 2011; Kastelic et al., 2022), but higher to others (Mensah et al., 2016; Rees-Punia et al., 2019; Visser & Koster, 2013). Regarding reliability, the total SB variable from the QMov24h ($ICC=0.80$) outperformed

most SB questionnaires (ICC=0.66) (Prince et al., 2020). It also demonstrated good agreement in the test-retest reliability, without any proportional bias between the two questionnaire administrations. In contrast, others found an overestimation of the first administration of the questionnaire (Lynch et al., 2014).

Regarding light PA variables, given the fact that LPA has only recently been included in the WHO guidelines (Bull et al., 2020), and given that evidence on the health-related benefits of LPA is quite recent (Chastin et al., 2019; Fuezeki et al., 2017), there are few questionnaires assessing it (Helmerhorst et al., 2012; Rodrigues, Encantado, Carraça, Sousa-Sá, et al., 2022; Tanaka et al., 2023). Recently, the Sedentary Behaviour and Light-intensity Physical Activity Questionnaire, focusing on LPA and SB measurement was developed (Tanaka et al., 2021), showing adequate validity ($\rho=0.43$) and reliability (ICC=0.70). However, it does not assess all PA intensities or sleep, limiting its ability to capture the 24-hour movement behaviours *continuum*. The QMov24h questionnaire has moderate validity ($\rho=0.33$) and good reliability (ICCs=0.84), making it one of the first questionnaires to assess light PA with valid and reliable questions. The DABQ (Kastelic et al., 2022) has validity ($\rho=0.45$) for LPA, but it does not include specific questions for light PA. Instead, LPA is *a posteriori* calculated as the remaining time to the total time spent MVPA.

Regarding aerobic MVPA variables, the results were generally comparable to or even higher than those found in other validation studies, such as the IPAQ (Craig et al., 2003), and GPAQ (Bull et al., 2009). Additionally, the QMov24h demonstrated a Spearman correlation of 0.53 in aerobic MVPA, indicating better criterion validity for this intensity than almost all of the questionnaires included in a recent systematic review on the measurement properties of movement behaviours questionnaires (Rodrigues, Encantado, Carraça, Sousa-Sá, et al., 2022). Bland Altman analysis presented a good agreement between the accelerometer and QMov24h, albeit with an overestimation of aerobic MVPA from the questionnaire (15.1 ± 88.3 min/day). In contrast, others overestimated 46 min/day (GPAQ) and 76 min/day (IPAQ) of MVPA (Herrmann et al., 2013). Regarding reliability, the QMov24h showed

moderate to good agreements on the test-retest (ICC of 0.72 to 0.83; $p < 0.001$) and these results are consistent with those from GPAQ and are higher to the IPAQ (Helmerhorst et al., 2012).

The strength MVPA variables showed significant very strong associations with the diary (rho from 0.85 to 0.97; $p < 0.001$). Our review did not identify any properly validated questionnaires, that include questions about muscle strengthening activities (Rodrigues, Encantado, Carraça, Sousa-Sá, et al., 2022). A questionnaire that includes items related to muscle strengthening activities is of utmost importance. Although muscle strengthening activities have been included in the guidelines since 1995 (Pate et al., 1995), they are not typically measured in clinical and surveillance studies. The current WHO PA guidelines (Bull et al., 2020), and the Canadian 24-h movement guidelines (Ross et al., 2020), only mention the frequency of muscle-strengthening activities. However, our questionnaire goes beyond this and asks about the duration of time spent on these activities. In this regard it would be ideal to have a questionnaire that included other domains of strength, such as intensity, sets and repetitions. However, this would make the questionnaire longer and more complex. Additionally, research has shown that engaging in muscle-strengthening activities is beneficial, regardless of the specific characteristics of the activities (Currier et al., 2023). Certainly, assessing, monitoring, and exploring health-related associations of the frequency and duration of muscle-strengthening activities, with valid and reliable questions at a population level, will be paramount for future updates of the guidelines. The same applies to the questions on balance activities. Although balance activities are typically only mentioned in guidelines for older adults (Bull et al., 2020), these are still important health-related activities across the lifespan. Besides that, the recently created 24-hour movement guidelines for Finland (UKK Institute, 2022), already include balance activities for adults. Additionally, the inclusion of this variable in QMov24h is justified by the ongoing validation studies for older adults of the QMov24h, as we intend to have one single questionnaire that can assess 24-hour movement behaviours in a standardized way throughout adulthood (>18 years).

To assess the compliance with the 24-hour movement guidelines, we dichotomised the continuous variables related to the guidelines (e.g., number of times of muscle-strengthening activities, minutes of aerobic MVPA, etc.), into 'comply' or 'not comply' with the guidelines. The results showed an adequate validity (69% to 94.3% of agreement) and reliability (k of 0.38 to 0.87; 80.3% to 94.0% of agreement) in compliance with the Canadian 24-hour movement guidelines. The use of open-ended questions with subsequent categorization of responses proved to be a stronger methodology than presenting closed response options (Danquah et al., 2018). Indeed, fixed categorical response options may not capture the full spectrum of possible responses, limit analysis of dose-response effects, and compromise further categorization. Additionally, pre-defined categories as response options may also affect how respondents perceive and answer questions (De Leeuw et al., 2012; Dillman et al., 2014). Furthermore, our questionnaire will remain suitable for application even if the guidelines change.

The QMove24h has the advantage of being adapted to the new reality of the recommendations by including questions on LPA, muscle strengthening and balance activities; questions that the most used questionnaires currently do not have. Besides that, the QMove24h can be used to measure the levels of the three movement behaviours in combination or individually, as well as compliance with the 24-hour movement guidelines or the new WHO recommendations for adults.

To obtain more accurate data on movement behaviours, questionnaires may be complemented with device-based data from devices such as accelerometers, due to their precision. While accelerometry cannot capture all types of activities accurately, such as muscle-strengthening and balance activities, questionnaires can gather valuable contextual information about the behaviours, such as type, domain or setting, that device-based measures are unable to (Lippke et al., 2013). Nevertheless, when assessing movement behaviours with accelerometers, data collection and processing methods are dependent on researchers' individual decisions. This makes these instruments susceptible to subjective decisions, which can potentially preclude meaningful

between-study comparisons (Pedišić & Bauman, 2015). To overcome these limitations, there is a need for a consensus about accelerometry methodological decisions. However, this may be a challenging task due to the complexity of procedures, the variety of available accelerometers, and the multitude of program options. In this sense, we conducted Paper IV to systematically review existing accelerometry methodological procedures for assessing 24-hour movement behaviours, across all age groups; baseline information to eventually propose standardization procedures. This review analysed 102 studies and found a substantial heterogeneity among reports, highlighting the wide range of options available for assessing 24-hour movement behaviours using accelerometry and the lack of *consensus* among researchers. Likewise, the review showed that several reports did not disclose all methodological decisions made to assess movement behaviours. This is an important shortcoming because, predetermined methodological decisions, such as data collection procedures and processing criteria, have a substantial impact on accelerometer data interpretation (Burchartz et al., 2020; Migueles et al., 2017; Quante et al., 2015).

Paper IV revealed that the Actigraph GT3X is the most commonly used accelerometer, with placement on the hip for those under 18 and on the wrist for those over 18. To ensure accurate data collection for all behaviours, some researchers opt to use both wrist and hip accelerometers simultaneously. Wrist-worn accelerometers seem to be more precise for assessing sleep quality metrics, while hip-worn accelerometers may be better for measuring sleep timing and quantity metrics (Smith et al., 2020). Hip-worn accelerometers are the preferred option for assessing (mainly MVPA), while thigh-worn accelerometers (e.g., ActivPal) are better suited for assessing posture behaviours, such as SB (Rosenberger et al., 2016). It is important to note that the devices used in each location can produce different metrics for each behaviour. (Ancoli-Israel et al., 2003; Trost et al., 2005). Ideally, research should aim to understand the best accelerometer model and body placement for capturing sleep, SB, and PA in an integrated fashion, without requiring multiple devices on participants. However, to the best of our knowledge, there are

currently no valid algorithms for achieving this without changing the accelerometer's placement. Incorporating inclinometers and additional sensors, such as temperature and heart rate, accelerometers may provide improved solutions for assessing movement behaviours while reducing the burden on participants and researchers. The Actiheart is a good example of accelerometer with multiple sensors (Barreira et al., 2009). However, to the best of our knowledge, there are no validation studies on 24-hour movement behaviours using this accelerometer.

Our review indicates that the most commonly used methods for determining a valid week include a recording of at least seven days, with a criterion of at least three weekdays and at least one weekend day which is in line with previous recommendations (Migueles et al., 2017). This recommendation emphasizes the importance of capturing both work/weekday and non-work/weekend days. This is crucial, considering the typical differences in patterns between these types of days (Trost et al., 2000; Ward et al., 2005).

For a day to be considered valid, 10 waking hours per day is the most commonly used criterion, except in studies involving toddlers and preschoolers, where the most commonly used criterion for a day to be considered valid is 24 hours. A 24-hour protocol and a recording of at least seven days, with a criterion of at least three weekdays and at least one weekend day to be considered a valid week and 16h to be considered a valid day, have been recommended (Migueles et al., 2017; Tudor-Locke et al., 2015). Short data collection periods as 1-3 days, may be useful for assessing movement behaviours in a specific context, such as a working day or a physical education class. On the other hand, it may be necessary to collect data for at least seven days to accurately measure movement behaviours throughout daily life (Addy et al., 2014; Barreira et al., 2015).

To overcome non-wear time, some researchers have been opting for missing data imputation. Nevertheless, manual input of non-wear time through diaries is time-consuming and can introduce subjectivity to the accelerometry analysis. In contrast, the use of algorithms to handle non-wear periods is less time-consuming and more objective (Burchartz et al., 2020). However, there are

different algorithms for different age groups, and further studies are necessary to test their precision (Migueles et al., 2017). Our review revealed a significant variation in how researchers handle missing data, with the most common criteria being ≥ 20 or ≥ 60 minutes of consecutive zero counts. The first criteria (≥ 20 minutes of consecutive zeros) was often applied to children, due to their more intermittent activity patterns. The second criterion (i.e., ≥ 60 minutes of consecutive zeros) is more commonly applied to adults. Some evidence suggests that a criterion of at least 90 minutes of consecutive zero counts may be more appropriate for older adults (Choi et al., 2012).

As for epochs, our review showed that, although there is no internationally accepted *consensus* (Burchartz et al., 2020), the most commonly used epochs for youth and adults are 15 and 60 seconds, respectively. Due to the spontaneous and intermittent nature of children's movement behaviours (Banda et al., 2016), epochs between 1-15 seconds are recommended (Aibar et al., 2014; Migueles et al., 2017). For sleep, it is recommended to use 60-second epochs (Cole et al., 1992; Sadeh et al., 1994; Tudor-Locke et al., 2014). To allow comparability between studies and data pooling, the shorter the epoch the better (Migueles et al., 2017). Regarding sampling rate, it is known that sampling rates of multiples of 30 hertz are more accurate (Burchartz et al., 2020), while non-multiples of 30 hertz could result in an increase of activity counts (Brønd & Arvidsson, 2016). Therefore, it is currently recommended to use the highest possible sampling rate (Migueles et al., 2017).

For studies on 24-hour movement behaviours, the most commonly used output is temporal units such as minutes or hours per day or week.

Regarding algorithms, from the studies included in our review, it was possible to observe that the Sadeh et al., 1994 and Cole–Kripke et al., 1992 sleep algorithms have been the most commonly used in children and adults, respectively. Previous studies have reported that, when using existing algorithms, the wrist-worn accelerometers are more precise in assessing sleep activity, when compared with other locations (Hjorth et al., 2012; Middelkoop et al., 1995; Zinkhan et al., 2014). However, such advantage can be overcome if sleep behaviour is visually analysed and manually scored, with the support of

information from diaries. Regarding SB and PA, the Pate et al., 2006 for toddlers and preschoolers, the Evenson et al., 2008 for children, the Hildebrand et al., 2014 and 2017 for adolescents and the Freedson et al., 1998 for adults and older adults have been the most frequently used cut-points in studies assessing 24-hour movement behaviours. When selecting a sleep algorithm and SB/PA cut-points to handle accelerometer data, it is important to choose age-appropriate options. Additionally, data collection and processing should follow the same procedures and decisions as the original validation/calibration study.

The most used procedure for handling non-compliant participants in all age group is the exclusion from the analysis.

Although logs or diaries were not commonly used in studies with toddlers, preschoolers, and children, these instruments should be employed to complement the data obtained from the accelerometer. (Quante et al., 2015).

A future consensus on methodological choices in accelerometry could combine the findings of this review and others that focus more on the quality of individual methodological choices (de Vries et al., 2006; Lettink et al., 2022; Lynch et al., 2019; Migueles et al., 2017).

Chapter 9

- Strengths and limitations
- Future research implications
- Conclusions

9.1. Strengths and limitations

To our knowledge, Papers I and II were the first to analyse the content characteristics and measurement properties of questionnaires that assess the three movement behaviours individually and in combination.

The reviews evaluated the content characteristics and measurement properties of questionnaires according to the COSMIN guidelines. This approach strengthens our work. The eligibility criteria, which required questionnaires to have both validity and reliability and a minimum of 50 participants for validity studies, ensured the exclusion of questionnaires with methodological shortcomings or incomplete validation processes. The use of COSMIN's proposed cutoff points to evaluate the quality of measurement properties increases the demand for appraising the content and measurement properties of the questionnaires included. However, these studies were not without limitations, as comparing the measurement properties of movement behaviours questionnaires complex, due to the heterogeneity of the data, such as different scores and domains, variety of recall periods, different comparison measures, reporting units and statistics. Although the use of the COSMIN guidelines is a strength it may have led, nonetheless to the loss of some information due to the mechanistic way of analysing the data. For example, a given questionnaire, while is classified as having an overall “inadequate” validity, may still be suitable for evaluating specific constructs from the items with 'adequate' validity scores. It is important to note that these reviews followed an adaptation of the COSMIN guidelines, and other reviews may have used different assumptions and guidelines with varying cutoffs. Therefore, direct comparisons between reviews should be made with caution.

Regarding the paper III, a major strength of the study was the rigorous methodological approach used to develop the QMov24h. The study followed the guidelines of design and analysis of the COSMIN, which included a three-stage approach: i) item construction; ii) face validity with end-users; and iii) content validity with movement behaviour experts from across the country. These procedures were essential to minimize participant reporting errors by ensuring that questions and instructions were adequately worded for the target

population. Another strength was the combination of accelerometry with a contextualized diary.

The questionnaire was developed to address some of the shortcomings in previously developed questionnaires. Face and content validity were performed, and questions on the three movement behaviours were included using a 24-hour continuum logic. Additionally, questions on light PA, muscle strengthening, and balance activities were included, which aligns with current guidelines. The QMov24h was designed to be informative, self-explanatory, and visually appealing to avoid response bias and minimize recall errors.

Paper III has some limitations. Firstly, a convenience sample was used, which may have influenced the results. The sample consisted largely of students, resulting in a possible imbalance between the group of young adults and middle-aged adults. Secondly, the study design only employs a single accelerometer placed on the hip, rather than a combination of accelerometers on the hip for PA, on the thigh for SB, and on the wrist for sleep. However, such study design would significantly increase the burden on participants and researchers. This is a limitation because, different accelerometers and body placements have varying strengths and weaknesses. For instance, wrist-worn accelerometers seem to be more precise in assessing sleep quality metrics, while hip-worn accelerometers may be better for sleep timing and quantity metrics (Smith et al., 2020). Hip-worn accelerometer has been shown as the best body placement for PA (mainly MVPA) and thigh-worn accelerometers (e.g., ActivPal) for posture behaviours (e.g., SB) (Rosenberger et al., 2016).

Finally, Paper IV provides a comprehensive summary of the most important methodological decisions related to accelerometry, including data collection and processing procedures. This includes a description of the cut-points and algorithms used in all the included reports. This review adds another layer to the decisions that need to be made when preparing to collect data on 24-hour MovBeh by helping researchers to define accelerometry protocols. The review also did not impose a date limit on the literature search, resulting in a review with a high number of included papers. Since the review included all types of accelerometers (brands and models), its results should be interpreted

taking into consideration that different accelerometers have specific characteristics. It is also important to note that this review was limited to reporting the most common procedures regarding methodological decisions for accelerometry, without considering measurement properties and validation/calibration studies. Therefore, this review should not be considered a list of best practices for the use and processing of accelerometry data. Instead, it should be viewed as a compilation of the most commonly used methods in studies that measure all movement behaviour over a 24-hour period, which can be used as a useful resource in any future consensus on this topic.

9.2. Future research implications

The QMov24h is the first validated questionnaires for Portuguese adults, allowing the assessment of sleep duration, SB and PA in an integrated fashion, as well as the compliance with guidelines. In this sense, this questionnaire is suitable for use in epidemiological research, health surveillance, and clinical studies due to its content, format, and measurement properties, and can be further validated in as many languages as possible. Therefore, as the Portuguese 24-hour movement guidelines are currently under development, the QMov24h can be used in the future to assess compliance with these guidelines at a national level, to support future interventions and public health decisions.

While the development and validation of QMov24h were informed by the systematic review on movement behaviour questionnaires, the scoping review on accelerometer methodologies has enabled us to identify the most common methodological decisions used in studies measuring 24-hour movement behaviours. A future consensus on these decisions could combine the data obtained in this review with data from other reviews that focus more on the quality of each methodological decision (de Vries et al., 2006; Lettink et al., 2022; Lynch et al., 2019; Migueles et al., 2017).

9.3. Conclusions

There are several questionnaires with different characteristics and outputs for all movement behaviours in isolation or in combination. However, these present frequent methodological shortcomings, resulting in inadequate validity and reliability scores. Existing questionnaires either have insufficient measurement properties or were not developed considering the 24-hour movement behaviours paradigm. There is a lack of valid and reliable questionnaires that assess 24-hour movement behaviours in an integrated way, which is hindering the development of accurate monitoring and surveillance systems, that allow adequate evaluation of 24-hour movement behaviours compliance.

We have developed a questionnaire, to assess 24-hour movement behaviours in adults as a response to the gaps found in existing questionnaires. The QMov24h is a valid and reliable tool for assessing movement behaviours and compliance with guidelines in adults. Its measurement properties are comparable or even higher to those of existing questionnaires, while posing a similar burden to participants. The QMov24h is useful for research, clinical practice, and public health surveillance.

There is a substantial variation in accelerometer protocols and methodological decisions applied by researchers to assess 24-hour movement behaviours. Therefore, to enhance precision and enable comparability between studies and countries, a consensus on methodological decisions is necessary. This is a challenging endeavour due to the complexity of the procedures, the variety of available accelerometer brands and types, and the multitude of programming options.

Chapter 10

- References

10.1. References

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Chapter 11

- Appendices

11.1. Appendix A – Consent form for interviews and focus groups for face validity with end-users

CONSENTIMENTO INFORMADO, LIVRE E ESCLARECIDO PARA PARTICIPAÇÃO EM INVESTIGAÇÃO

de acordo com a Declaração de Helsínquia¹ e a Convenção de Oviedo²

Entrevista/grupos focais – utilizador – Questionário Recomendações 24h Movimento –
maiores de 18 anos (versão em papel)

Gostaríamos de o convidar a participar num estudo científico. Por favor, leia com atenção a seguinte informação. Se achar que algo está incorreto ou que não está claro, não hesite em solicitar mais informações, utilizando os contactos em baixo listados. Se concorda com a proposta que lhe é feita, queira assinar este documento.

Título do estudo:

MOVE24: Divulgação, Monitorização e Vigilância das Recomendações Portuguesas 24h Movimento: fazer com que o dia inteiro seja importante.

Enquadramento:

As Recomendações Portuguesas 24h Movimento servirão de base para a futura vigilância em saúde pública e fornecerão informação prática a clínicos, investigadores e população em geral. Complementarmente, serão necessários novos questionários para mensurar a adesão às recomendações e determinação de níveis dos comportamentos de movimento. Este projeto está a ser desenvolvido pela Faculdade de Desporto da Universidade do Porto.

Explicação da recolha de dados:

Enquanto futuro utilizador das novas recomendações 24h movimento, convidamo-lo a participar numa entrevista acerca da versão preliminar do questionário que estamos a desenvolver, que visa discutir dificuldades, barreiras, e constrangimentos no preenchimento do questionário e avaliar a legibilidade, clareza, ambiguidades, processo e estratégias utilizadas para responder às perguntas. Além disso, irão ser avaliadas, atitudes gerais em relação às perguntas, tempo necessário para responder a todas as perguntas e se as instruções de preenchimento são claras e

¹ https://www.ordemdosmedicos.pt/up/ficheiros-bin2_ficheiro_pt_0077090001371555285-672.pdf

² <http://dre.pt/pdf1sdip/2001/01/002A00/00140036.pdf>

suficientes. Como tal, irá ser questionados sobre cada um dos itens ao nível do seu conteúdo, mas também ao nível da sua construção, relevância, compreensão, abrangência, e constrangimentos de resposta. As suas **respostas são importantes**, esteja à vontade para ser o mais honesto possível, pois os seus pontos de vista e ideias ajudar-nos-ão a melhorar o nosso questionário. Não existem respostas ou opiniões certas ou erradas – todas são válidas.

Condições e financiamento:

A sua participação é voluntária e pode recusar-se a participar. Caso decida participar neste grupo focal/entrevista, é importante ter conhecimento que pode desistir a qualquer momento, sem qualquer tipo de consequência para si. Não se anteveem quaisquer riscos decorrentes da participação no presente estudo. Este projeto é financiado pela Fundação para a Ciência e Tecnologia (número de identificação do projeto: PTDC/SAU-DES/0166/2021), tendo merecido parecer favorável da Comissão de Ética da Faculdade de Desporto, da Universidade do Porto (com o número de identificação CEFAD 17 2022).

Confidencialidade e anonimato

Os temas a abordar neste grupo focal/entrevista não são sensíveis do ponto de vista pessoal. A participação de em grupos focais implica sempre que todos os participantes e o investigador conheçam a sua identidade. Será pedido a todos os participantes sigilo. Todas as informações registadas são estritamente confidenciais e serão usadas unicamente com propósitos científicos de investigação e de desenvolvimento de políticas de saúde pública nacionais, nunca sendo tornada pública a identificação dos participantes.

Apenas os membros da equipa de investigação ou outros investigadores autorizados poderão utilizar os dados recolhidos (gravados e transcritos), que serão analisados de forma anónima e conservados sigilosamente (apenas será registado o seu código de ID) durante 10 anos após o termo do estudo (de acordo com as boas práticas de investigação). Os resultados deste estudo serão posteriormente divulgados em congressos científicos, revistas científicas e imprensa.

Responsável pela entrega deste consentimento informado (nome e assinatura):

Declaro ter lido e compreendido este documento, bem como as informações verbais que me foram fornecidas pela pessoa que acima assina. Foi-me garantida a possibilidade de, em qualquer altura, recusar participar neste estudo sem qualquer tipo de consequências. Desta forma, aceito participar neste estudo e permito a utilização dos dados que de forma

voluntária forneço, confiando em que apenas serão utilizados para esta investigação e nas garantias de confidencialidade e anonimato que me são dadas pelo/a investigador/a.

☐ Aceito gravação de som e imagem da entrevista/grupo focal.

Nome do participante:

Assinatura do participante:

Data: ____ / ____ / ____

Muito obrigado pela sua participação neste estudo!

Coordenação do estudo: Professora Doutora Rute Santos, Faculdade de Desporto da Universidade do Porto

Contactos: TELEFONE: +351 220425200 | E-MAIL: rsantos.ciafel@fade.up.pt |

Morada: Faculdade de Desporto da Universidade do Porto, R. Dr. Plácido da Costa 91, 4200-450 Porto.

Entidade Promotora: Faculdade de Desporto da Universidade do Porto

Entidade Copromotora: Instituto de Saúde Pública da Universidade do Porto

ESTE DOCUMENTO É COMPOSTO POR 2 PÁGINAS E FEITO EM DUPLICADO: UMA VIA PARA O/A INVESTIGADOR/A, OUTRA PARA A PESSOA QUE CONSENTE.



11.2. Appendix B - Semi-structured guide for interviews and focus groups with end-users for face validity

Projeto MOVE24

Guia semiestruturado para entrevista e grupos focais adultos – maiores de 18 anos

Iniciais do Mediador |__|__|__| Iniciais do Observador (se aplicável) |__|__|__|

Data |__|__|__|/|__|__|/|__|__| Ficheiro vídeo/áudio: |__|__|__|

Idade do entrevistado: _____

Introdução

Antes de mais, obrigado pela sua disponibilidade. O meu nome é _____ e vou fazer-lhe algumas perguntas sobre formação contínua no âmbito das Recomendações 24h movimento para a População Portuguesa. Começando a falar-vos deste projeto:

- **Enquadramento:** Estão a ser desenvolvidas novas recomendações de 24 horas para os comportamentos de movimento da população portuguesa. Estas recomendações servirão de base para a futura vigilância e monitorização em saúde pública e fornecerão informação prática a clínicos, investigadores e população em geral. Complementarmente, serão necessários novos questionários para mensurar a adesão às recomendações e determinação de níveis dos comportamentos de movimento. Este projeto está a ser desenvolvido pela Faculdade de Desporto da Universidade do Porto e é financiado pela Fundação para a Ciência e a Tecnologia.
- **Objetivos da entrevista e duração esperada:** Primeiro irá analisar o questionário sobre os comportamentos de movimento durante as 24 horas do dia, que pretendemos validar. Depois disso, daremos início à entrevista que terá uma duração aproximada de uma hora e com ela queremos saber o que pensa ao nível da sua legibilidade, clareza e ambiguidades, processo e estratégias utilizadas para responder às perguntas. Como tal, irá ser questionados sobre cada um dos itens ao nível do seu conteúdo, mas também ao nível da sua construção, relevância, compreensão, abrangência, e constrangimentos de resposta. As suas **respostas são importantes**, esteja à vontade para ser o mais honesto possível, pois os seus pontos de vista e ideias ajudar-nos-ão a melhorar o nosso questionário.
- **À semelhança de qualquer outra entrevista, pretende-se um debate livre de ideias e experiências. Não há respostas certas ou erradas** para as perguntas - apenas **ideias, experiências e opiniões**, que são valiosas. Se a sua opinião mudar ao longo da sessão, não hesite em dizê-lo. É importante **ouvirmos os dois lados de uma questão** - o positivo e o negativo.

Está **garantida a confidencialidade**. Todas as análises feitas serão **anónimas**, pois o seu autor não será **identificado**.

- **Com o seu consentimento**, gostaríamos de **gravar esta entrevista**. Os dados serão mantidos em sigilo.
- Quer colocar alguma questão?

Instruções para o mediador / observador: Ativar e verificar a gravação; assegurar-se de que o participante deu consentimento para participar na entrevista e para a mesma ser gravada.

Domínio	Tópico e Pistas
Para esta primeira parte da discussão, vamos falar sobre os conceitos que o questionário aborda e sobre a introdução do questionário. Mais tarde falaremos sobre cada bloco de perguntas.	

Conceitos	1. Quais são os comportamentos do movimento que podemos realizar ao longo de 24 horas? 2. O que é o sono? 3. O que é uma sesta? 4. O que é o comportamento sedentário? 5. O que é a atividade física? 6. O que é atividade física aeróbia? 7. O que é atividade física de fortalecimento muscular? 8. O que é uma atividade de intensidade ligeira? 9. O que é uma atividade de intensidade moderada? 10. O que é uma atividade de intensidade vigorosa?
Preâmbulo do Questionário	11. Quando leu a introdução do questionário, o que entendeu sobre o que tratava o questionário? 12. Surgiram algumas dúvidas à partida? 13. Sentiu necessidade de mais alguma informação inicial? 14. Quando dizemos que apenas pode realizar cada comportamento um de cada vez e que o nosso dia apenas tem 24 horas, o que entendeu? 15. Considera que compreendeu as instruções, ao ponto de não ser necessária mais nenhuma informação? 16. Ficou claro que o questionário pretende informação sobre um dia típico da sua vida, seja num dia de escola, seja num dia de fim de semana? <i>Se não: perguntar qual a parte dos itens que foi confusa. Se sim: ok</i>
Sono e sestas	17. O que acha das definições de sono e sestas? 18. Compreendeu-as? <i>Se não: perguntar o que não entendeu. Se sim: ok</i> 19. Seria necessária mais alguma informação para as completar? 20. O que compreendeu das perguntas efetuadas? 21. Como descobriu as horas e os minutos a escolher para as tuas respostas? 22. No que diz respeito ao objetivo de medir o sono num dia típico, achou as perguntas relevantes? 23. Ficou claro que o pretendido é medir o tempo, ou seja, as horas, que passa a dormir e a fazer a sesta num dia de escola e num dia de fim de semana? <i>Se não: perguntar qual a parte dos itens que foi confusa. Se sim: ok</i> 24. Seria necessária mais alguma informação para a completar? 25. Quão fácil foi para si caracterizar o tempo de sono noturno e de sesta ao longo do dia? 26. Teve alguma dúvida?
Comportamento sedentário	27. O que achou da definição de comportamento sedentário? 28. Compreendeu-a? <i>Se não: perguntar o que não entendeu. Se sim: ok</i> 29. Seria necessária mais alguma informação para a completar? 30. O que compreendeu das perguntas efetuadas? 31. Como descobriu as horas e os minutos a escolher para as tuas respostas? 32. Ficou claro que o pretendido é medir o tempo, ou seja, as horas, que passas sentado, reclinado ou deitado enquanto está acordado, num dia de escola e num dia de fim de semana? <i>Se não: perguntar qual a parte dos itens que foi confusa. Se sim: ok</i> 33. O que compreendeu que deveria responder na pergunta sobre o tempo de ecrã? 34. O que compreendeu que deveria responder na pergunta sobre o tempo em transporte?

	ativo? 35. Seria necessária mais alguma informação para completar as perguntas? 36. Teve alguma dúvida? 37. Achou todas as perguntas relevantes no que diz respeito à mensuração do comportamento sedentário? 38. Quão fácil foi para si caracterizar o teu tempo em comportamento sedentário ao longo do dia?
Atividade Física	39. O que achou da definição de atividade física? 40. O que achou da definição de atividade física aeróbia? 41. O que achou e da definição de atividades de fortalecimento muscular? 42. O que achou das definições das várias intensidades? 43. Compreendeu-as? <i>Se não: perguntar o que não entendeu. Se sim: ok</i> 44. Acha que a escala de esforço ajuda a compreender as intensidades? 45. Seria necessária mais alguma informação para a completar? 46. O exemplo ajudou?
Atividade Física Ligeira	47. O que compreendeu das perguntas efetuadas? 48. Como descobriu as horas e os minutos a escolher para as tuas respostas? 49. Ficou claro que o pretendido é medir o tempo, ou seja, as horas, que passa em atividades de intensidade ligeira num dia de escola e num dia de fim de semana? <i>Se não: perguntar qual a parte dos itens que foi confusa. Se sim: ok</i> 50. Seria necessária mais alguma informação para completar as perguntas? 51. Teve alguma dúvida? 52. Achou todas as perguntas relevantes no que diz respeito à mensuração do tempo em atividade física de intensidade ligeira? 53. Quão fácil foi para si caracterizar a sua atividade física aeróbia ligeira ao longo do dia com base nestas perguntas? 54. Quão fácil foi para si caracterizar a sua atividade física de fortalecimento muscular de intensidade ligeira ao longo do dia com base nestas perguntas?
Atividade Física Moderada	55. Neste contexto, que achou das perguntas de organização semanal nesta intensidade? Facilita ou é mais fácil da forma como estão organizados ou outros blocos? 56. O que compreendeu das perguntas efetuadas? 57. Como descobriu as horas e os minutos a escolher para as tuas respostas? 58. Ficou claro que o pretendido é medir o tempo, ou seja, as horas e os minutos, que passa em atividades de intensidade moderada, nos dias de escola e nos dias de fim de semana? <i>Se não: perguntar qual a parte dos itens que foi confusa. Se sim: ok</i> 59. Seria necessária mais alguma informação para completar as perguntas? 60. Teve alguma dúvida? 61. Achou todas as perguntas relevantes no que diz respeito à mensuração do tempo em atividade física de intensidade moderada? 62. Quão fácil foi para si caracterizar a sua atividade física aeróbia moderada ao longo dos dias com base nestas perguntas? 63. Quão fácil foi para si caracterizar a sua atividade física de fortalecimento muscular de intensidade moderada ao longo dos dias com base nestas perguntas?
Atividade Física	64. Neste contexto, que achou das perguntas de organização semanal nesta intensidade?

Vigorosa	Facilita ou é mais fácil da forma como estão organizados ou outros blocos? 65. O que compreendeu das perguntas efetuadas? 66. Como descobriu as horas e os minutos a escolher para as tuas respostas? 67. Ficou claro que o pretendido é medir o tempo, ou seja, as horas e os minutos, que passa em atividades aeróbias de intensidade vigorosa, nos dias de escola e nos dias de fim de semana? <i>Se não: perguntar qual a parte dos itens que foi confusa. Se sim: ok</i> 68. Seria necessária mais alguma informação para completar as perguntas? 69. Teve alguma dúvida? 70. Achou todas as perguntas relevantes no que diz respeito à mensuração do tempo em atividade física vigorosa? 71. Quão fácil foi para si caracterizar a sua atividade física aeróbia vigorosa ao longo dos dias com base nestas perguntas? 72. Quão fácil foi para si caracterizar a sua atividade física de fortalecimento muscular de intensidade vigorosa ao longo dos dias com base nestas perguntas?
Exercícios de equilíbrio	73. O que achou da definição de exercícios de equilíbrio? 74. Compreendeu-a? Se não: perguntar o que não entendeu. Se sim: ok 75. Seria necessária mais alguma informação para completar esta definição? 76. O que compreendeu das perguntas efetuadas? 77. Como descobriu as horas e os minutos a escolher para a sua resposta? 78. Ficou claro que o pretendido é medir o tempo, ou seja, o numero de dias, as horas e os minutos, que passa em exercícios de equilíbrio, no dias de trabalho e nos dias de folga? <i>Se não: perguntar qual a parte dos itens que foi confusa. Se sim: ok</i> 79. Seria necessária mais alguma informação para completar as perguntas? 80. Teve alguma dúvida? 81. Achou todas as perguntas relevantes no que diz respeito à mensuração do tempo em atividades de equilíbrio? 82. Quão fácil foi para si caracterizar os seus momentos de exercícios de equilíbrio ao longo dos dias com base nestas perguntas?
Geral	83. Quanto tempo demorou a responder ao questionário? 84. As instruções ao longo do questionário foram claras? 85. O que achou das opções de resposta, aplicadas ao longo de todo o questionário? 86. Quais foram as maiores dificuldades? Alguma solução? 87. Das coisas de que falámos, o que é que mais se destacou para si? 88. Sente que disseste o que realmente estavas a pensar? 89. Há mais alguma coisa que gostaria de acrescentar?
Encerramento <u>Nota para o mediador:</u> Agradecer ao entrevistado	

11.3. Appendix C – Consent form for interviews and focus groups for content validity with experts

CONSENTIMENTO INFORMADO, LIVRE E ESCLARECIDO PARA PARTICIPAÇÃO EM INVESTIGAÇÃO

de acordo com a Declaração de Helsínquia³ e a Convenção de Oviedo⁴

Entrevista/Grupo Focal - Validade facial e de conteúdo para informar questionários 24 horas do movimento

Gostaríamos de o convidar a participar num estudo científico. Por favor, leia com atenção a seguinte informação. Se achar que algo está incorreto ou que não está claro, não hesite em solicitar mais informações, utilizando os contactos em baixo listados. Se concorda com a proposta que lhe é feita, queira assinar este documento.

Título do estudo:

MOVE24: Divulgação, Monitorização e Vigilância das Recomendações Portuguesas 24h Movimento: fazer com que o dia inteiro seja importante.

Enquadramento:

As Recomendações Portuguesas 24h Movimento servirão de base para a futura vigilância em saúde pública e fornecerão informação prática a clínicos, investigadores e população em geral. Complementarmente serão necessários instrumentos de medição novos/adaptados para mensurar a adesão às recomendações e determinação de níveis de comportamentos de movimento. O Projeto está a ser desenvolvido pela Faculdade de Desporto da Universidade do Porto.

Explicação da recolha de dados:

Enquanto especialista em comportamentos do movimento, convidamo-lo a responder à versão preliminar do questionário que estamos a desenvolver e a participar numa entrevista, conduzida pela equipa de investigação, com gravação áudio ou vídeo (duração aproximada: 1 hora), que visa discutir possíveis dificuldades, barreiras, e constrições no preenchimento do

³ https://www.ordemdosmedicos.pt/up/ficheiros-bin2_ficheiro_pt_0077090001371555285-672.pdf

⁴ <http://dre.pt/pdf1sdip/2001/01/002A00/00140036.pdf>

questionário e avaliar a o que pensa ao nível da sua legibilidade, clareza e ambiguidades. Como tal, irá ser questionado sobre o seu conteúdo, mas também sobre a sua construção, relevância, compreensão, abrangência, e constrangimentos de resposta. Não existem respostas certas ou erradas – todas as respostas são válidas. O importante, para nós, é conhecer a sua opinião.

Condições e financiamento:

A sua participação é voluntária e pode recusar-se a participar. Caso decida participar nesta entrevista, é importante ter conhecimento que pode desistir a qualquer momento, sem qualquer tipo de consequência para si. Não se anteveem quaisquer riscos decorrentes da participação no presente estudo. Este projeto é financiado pela Fundação para a Ciência e Tecnologia (número de identificação do projeto: PTDC/SAU-DES/0166/2021), tendo merecido parecer favorável da Comissão de Ética da Faculdade de Desporto, da Universidade do Porto (com o número de identificação CEFAD 17 2022).

Confidencialidade e anonimato

Os temas a abordar nesta entrevista não são sensíveis do ponto de vista pessoal. Todas as informações registadas neste são estritamente confidenciais e serão usadas unicamente com propósitos científicos de investigação e de desenvolvimento de políticas de saúde pública nacionais, nunca sendo tornada pública a identificação dos participantes.

Apenas os membros da equipa de investigação ou outros investigadores autorizados poderão utilizar os dados recolhidos (gravados e transcritos), que serão analisados de forma anónima e conservados sigilosamente (apenas será registado o seu código de ID) durante 10 anos após o termo do estudo (de acordo com as boas práticas de investigação). Os resultados deste estudo serão posteriormente divulgados em congressos científicos, revistas científicas e imprensa. Nota importante: No contexto específico das entrevistas de grupo, devido à presença de outros participantes, a equipa de investigação não poderá assegurar a total confidencialidade dos temas abordados no seu grupo de entrevista, fora da esfera do estudo.

Responsável pela entrega deste consentimento informado (nome e assinatura):

Declaro ter lido e compreendido este documento, bem como as informações verbais que me foram fornecidas pela pessoa que acima assina. Foi-me garantida a possibilidade de, em qualquer altura, recusar participar neste estudo sem qualquer tipo de consequências. Desta forma, aceito participar neste estudo e permito a utilização dos dados que de forma

voluntária forneço, confiando em que apenas serão utilizados para esta investigação e nas garantias de confidencialidade e anonimato que me são dadas pelo/a investigador/a.

Nome do participante:

Assinatura do participante:

Data: ____ / ____ / ____

Muito obrigado pela sua participação neste estudo!

Coordenação do estudo: Professora Doutora Rute Santos, Faculdade de Desporto da Universidade do Porto

Contactos: TELEFONE: +351 220425200 | E-MAIL: rsantos.ciafel@fade.up.pt |

Morada: Faculdade de Desporto da Universidade do Porto, R. Dr. Plácido da Costa 91, 4200-450 Porto.

Entidade Promotora: Faculdade de Desporto da Universidade do Porto

Entidade Copromotora: Instituto de Saúde Pública da Universidade do Porto

ESTE DOCUMENTO É COMPOSTO POR 2 PÁGINAS E FEITO EM DUPLICADO: UMA VIA PARA O/A INVESTIGADOR/A, OUTRA PARA A PESSOA QUE CONSENTE.



11.4. Appendix D – Semi-structured guide for interviews and focus groups with experts for content validity

Projeto MOVE24

Guia semiestruturado para entrevista e grupos focais com especialistas – Validade Facial e de conteúdo

Iniciais do Mediador |__|__|__| Iniciais do Observador (se aplicável) |__|__|__|

Data |__|__|__|/|__|__|__|/|__|__| Ficheiro vídeo/áudio: |__|__|__|

Especialidade do entrevistado: _____

Introdução

Antes de mais, obrigado pela sua disponibilidade. O meu nome é _____ e vou fazer-lhe algumas perguntas sobre formação contínua no âmbito das Recomendações 24h movimento para a População Portuguesa. Começando a falar-vos deste projeto:

- **Enquadramento:** Estão a ser desenvolvidas novas recomendações de 24 horas para os comportamentos de movimento da população portuguesa. Estas recomendações servirão de base para a futura vigilância e monitorização em saúde pública e fornecerão informação prática a clínicos, investigadores e população em geral. Complementarmente, serão necessários novos questionários para mensurar a adesão às recomendações e determinação de níveis dos comportamentos de movimento. Este projeto está a ser desenvolvido pela Faculdade de Desporto da Universidade do Porto e é financiado pela Fundação para a Ciência e a Tecnologia.
- **Objetivos da entrevista e duração esperada:** Primeiro irá analisar o questionário sobre os comportamentos de movimento durante as 24 horas do dia, que pretendemos validar. Depois disso, daremos início à entrevista que terá uma duração aproximada de uma hora e com ela queremos saber o que pensa ao nível da sua legibilidade, clareza e ambiguidades. Como tal, irá ser questionados o seu conteúdo, mas também sobre a sua construção, relevância, compreensão, abrangência, e constrangimentos de resposta. As suas **respostas são importantes**, esteja à vontade para ser o mais honesto possível, pois os seus pontos de vista e ideias ajudar-nos-ão a melhorar o nosso questionário.
- **À semelhança de qualquer outra entrevista, pretende-se um debate livre de ideias e experiências. Não há respostas certas ou erradas** para as perguntas - apenas **ideias, experiências e opiniões**, que são valiosas. Se a sua opinião mudar ao longo da sessão, não hesite em dizê-lo. É importante **ouvirmos os dois lados de uma questão - o positivo e o negativo**.

Está **garantida a confidencialidade**. Todas as análises feitas serão **anónimas**, pois o seu autor não será identificado.

- **Com o seu consentimento**, gostaríamos de **gravar esta entrevista**. Os dados serão mantidos em sigilo.
- Quer colocar alguma questão?

Instruções para o mediador / observador: Ativar e verificar a gravação; assegurar-se de que o participante deu consentimento para participar na entrevista e para a mesma ser gravada.

Domínio	Tópico e Pistas
Começamos pelo preâmbulo do questionário.	
Preâmbulo do Questionário	90. Quando leu a introdução do questionário, o que entendeu sobre o que tratava o questionário?

	91. Sentiu necessidade de mais alguma informação inicial?
Sono e sesta	92. O que acha da definição de sono? 93. Seria necessária mais alguma informação para a completar? 94. O que achou das perguntas efetuadas ao nível da sua compreensão? 95. O que achou das perguntas efetuadas ao nível da sua relevância? 96. O que achou das perguntas efetuadas ao nível da sua abrangência? 97. Seria necessária mais alguma informação para a completar? 98. O que achou da definição de sesta? 99. Seria necessária mais alguma informação para a completar? 100. O que achou das perguntas efetuadas ao nível da sua compreensão? 101. O que achou das perguntas efetuadas ao nível da sua relevância? 102. O que achou das perguntas efetuadas ao nível da sua abrangência? 103. Seria necessária mais alguma informação para as completar?
Comportamento sedentário	104. O que achou da definição de comportamento sedentário? 105. Seria necessária mais alguma informação para a completar? 106. O que achou das perguntas efetuadas ao nível da sua compreensão? 107. O que achou das perguntas efetuadas ao nível da sua relevância? 108. O que achou das perguntas efetuadas ao nível da sua abrangência? 109. Seria necessária mais alguma informação para as completar?
Atividade Física aeróbia, força e equilíbrio	110. O que achou da definição de atividade física? 111. O que achou da definição de atividade física aeróbia? 112. O que achou da definição de atividades de fortalecimento muscular? 113. O que achou das definições das várias intensidades? 114. Acha que a escala de esforço ajuda a compreender as intensidades? 115. Seria necessária mais alguma informação para a completar? 116. O exemplo ajudou? 117. O que achou das perguntas efetuadas ao nível da sua compreensão? 118. O que achou das perguntas efetuadas ao nível da sua relevância? 119. O que achou das perguntas efetuadas ao nível da sua abrangência? 120. Seria necessária mais alguma informação para as completar?
Geral	121. As instruções ao longo do questionário foram claras? 122. O que achou das opções de resposta de horas e minutos, aplicadas ao longo de todo o questionário? 123. O que achou da utilidade das contas que pedimos para fazer ao longo do questionário? 124. Considerou importante perguntar em separado sobre o dia de folga/fim-de-semana e o de trabalho? 125. Há mais alguma coisa que gostaria de acrescentar?
Encerramento <u>Nota para o mediador:</u> Agradecer ao entrevistado	