Estrutura Multidimensional de Variáveis Correlatas dos Níveis de Atividade Física de Crianças. O Estudo ISCOLE Português

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Dissertação apresentada com vista à obtenção do grau de Mestre em Desporto para Crianças e Jovens (Decreto Lei n.º 74/2006, 24 de março), sob orientação do Professor Doutor José António Ribeiro Maia e co-orientação do Professor Doutor Daniel de Vilhena e Santos e Mestre Thayse Natacha Queiroz Ferreira Gomes.

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Palavras-Chave: ISCOLE, ATIVIDADE, RECOMENDAÇÃO, OMS, CRIANÇAS, VARIÁVEIS CORRELATAS, ESCOLA, MODELO

DEDICATÓRIA

Ao meu marido querido…

Lucas Cykman de Paula

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RESUMO

É hoje indiscutível o papel de níveis moderados a elevados de atividade física (AFMV) na prevenção e controlo de um conjunto variado de morbilidades crónicas, tanto em adultos como em crianças. Acresce o fato de um número cada vez maior de crianças e jovens de todo o mundo não cumprirem as recomendações da Organização Mundial de Saúde (OMS) relativamente ao número de minutos diários (60) de AFMV. Assim, a presente tese tem o seguinte propósito: identificar as variáveis correlatas, a nível das crianças e das escolas, seu sinal e magnitude, relativas ao cumprimento da recomendação diária de AFMV. A amostra, composta por crianças envolvidas no projeto internacional ISCOLE, é constituída por 777 crianças dos dois sexos com uma média etária de 10 anos, provenientes de 23 escolas da região Norte do país. Foi medida a altura e o peso, e calculado o índice de massa corporal (IMC). Informações sobre maturação biológica, atividade física, estilos de vida, ambiente familiar e escolar foram obtidas. A análise estatística compreendeu medidas descritivas e inferenciais. Dado que a variável dependente é uma contagem que segue uma distribuição de Poisson, recorreu-se a um modelo de regressão de contagens considerando, ou não, a estrutura hierárquica da informação obtida – alunos e escolas. Os resultados mostram que o número de crianças que cumpre as recomendações durante os sete dias da semana é baixo (8.3%), sendo os rapazes mais cumpridores. O sexo, o IMC, o transporte ativo, a renda familiar e o tempo passado fora da escola apresentaram-se como preditores relevantes em termos de sinal e magnitude; este modelo explicou 17% da variação total na realização das recomendações de AFMV durante os sete dias. Os resultados da modelação hierárquica mostraram que as variáveis individuais melhor explicam a variabilidade no cumprimento diário da AFMV, comparativamente às variáveis do contexto escolar. Estas informações devem ser levadas em consideração no planeamento de programas de promoção de atividade física e comportamentos saudáveis, que deve ser pensados por forma a envolver variáveis do domínio pessoal, familiar e escolar. Palavras-chave: ISCOLE, ATIVIDADE FÍSICA MODERADA A VIGOROSA, CRIANÇAS, ESCOLA.

ABSTRACT

It is well known that moderate-to-high physical activity (MVPA) levels have an important role in the prevention and control of many chronic diseases in adult and youth. Additionally, it has been pointed that the number of children complying the World Health Organization (WHO) daily MVPA guidelines (60 minutes/day) is low. So, the present thesis aims: to identify the children- and school-level MVPA recommendations achievement correlates, as well as its signal and magnitude. The sample of this study is part of the international project ISCOLE, and comprises 777 children, of both sexes, with mean age of 10 years, from 23 schools from the region of Porto. Height and weight were measured, and the body mass index (BMI) was calculated. Information regarding to biological maturation, physical activity, and lifestyle, familiar and school environment were also obtained. Statistical analysis comprises descriptive and inferential approaches. As the dependent variable is a count following a Poisson distribution, we used a count regression model considering, or not, the nested data structure (children and schools). Results showed that the number of children meeting the MVPA recommendations is low (8.3%), and boys tend to achieve the recommendations more than girls. Sex, BMI, active transportation, family income, and time spent outside the school were relevant predictors with different signs and effects; this model explained 17% of the total variation in achievement the MVPA recommendations during the seven days. The multilevel analysis showed that children correlates better explain the variability in the MVPA daily achievement than those variables from school context. Taken together, this information should be considered when the design of promotion physical activity and healthy behaviours programs, which should take account variables came from individual, familial and school domains

Key words: ISCOLE, MODERATE TO VIGOROUS PHYSICAL ACTIVITY, CHILDREN, SCHOOL.

Lista de Abreviaturas e Símbolos

%	Percentagem
<	Menor que
>	Maior que
≤	Menor ou Igual
≥	Maior ou Igual
±	Mais ou menos
≈	aproximadamente
~	similarmente
χ^2	Qui-quadrado
AF	Atividade Física
AFMV	Atividade física moderada a vigorosa
BMI	Body mass index
CI95%	Confidence Interval
e.g.	For example
ESE	Estaturo Sócio econòmico
HSBC	Health Behavior in School Aged Children
i.e.	Isto é
IMC	Índice de massa corpora
ISCOLE	International Study of Childhood Obesity, Lifestyle and the Environment
Kg	Quilograma
M	Mean
Min	Minute / Minuto
MVPA	Moderate-to-vigorous Physical Activity
OMS	Organização Mundial de Saúde
PA	Physical Activity
PBRC	Pennington Biomedical Research Center
PHV	Peak height velocity
SD	Standard Deviation
SE	Standard Error
SES	Socioeconomic Status
WHO	World Health Organization

Capítulo 1

Introdução Geral e Estrutura da Dissertação

Introdução Geral

Durante as últimas décadas, um conjunto substancial de evidências científicas mostraram os benefícios para a saúde advindos da prática regular de atividade física (AF)/exercício físico (Fuzhong & Fisher, 2004; Hayes et al., 2013; Janssen & LeBlanc, 2010; U.S. Dept. of Health and Human Services, 1996), incluindo a redução do risco de mortalidade por variadas causas, tais como co-morbidades associadas à obesidade e doenças cardiovasculares (Xue et al., 2012). A prevenção primária, através do estabelecimento de estilos de vida ativos durante a infância e adolescência, tem sido associada a uma diminuição do risco relativo de desenvolvimento de doenças crónicas na vida adulta (Malina et al., 2004). Por exemplo, diferentes estudos reportam a existência de *tracking*[1] do sobrepeso e obesidade, indicando que a obesidade em idade adulta, não raras vezes, tem a sua origem na infância e adolescência (McGee, 2005; Singh et al., 2008).

Historicamente, níveis elevados de AF nas crianças têm sido associados a uma menor propensão para desenvolver fatores de risco cardiometabólicos, excesso de peso, tabagismo e diabetes tipo II na idade adulta (Metzger et al., 2010). Por oposição, o sedentarismo das crianças é considerado um fator de risco cuja estrutura e dimensões são modificáveis, pelo que se reveste de grande urgência a promoção da participação regular em AF ao longo da infância, levando em consideração os seus benefícios para a saúde (World Health Organization, 2010)

Há uma diretriz atual que correlaciona aspetos da manutenção de estados saudáveis com níveis de AF total de, pelo menos, 60 minutos diários de atividades moderadas a vigorosas (AFMV) (World Health Organization, 2010). Contudo, apesar de conhecidos os benefícios da AFMV, dos quais decorre a importância em cumprir estas recomendações, existe uma grande variabilidade na percentagem de crianças que cumpre, ou não, os 60 minutos diários (Crespo et al., 2013; Laguna et al., 2013; Riddoch et al., 2004). Em termos genéricos, esta variabilidade tem sido atribuída a especificidades das

[1] *Tracking* refere-se à manutenção de um estado (por exemplo, obesidade) ou uma posição relativa (por exemplo, percentil 90) ao longo de um dado período de tempo.

populações estudadas, bem como a diferentes métodos e procedimentos de avaliação, concretamente o uso de diferentes valores de corte na definição de AFMV. Por exemplo, na população portuguesa, Baptista et al. (2012) descrevem a prevalência de crianças e jovens portugueses que cumprem as recomendações dos 60 minutos diários de AFMV. Referiram que apenas 36% das crianças, entre os 10 e 11 anos de idade, são suficientemente ativas, sendo os rapazes mais ativos que as raparigas (51.6% e 22.5%, respectivamente). Telford et al. (2013), num estudo longitudinal com crianças australianas de idades entre 8-12 anos, relataram que 31% dos rapazes e 16% das raparigas atingiram as recomendações diárias de AFMV. Em contraste, Verloigne et al. (2012), numa investigação que incluiu dados de sete países europeus (Bélgica, Grécia, Hungria, Países Baixos, Noruega, Eslovénia e Espanha), salientaram que apenas 4.6% das raparigas e 16.8% dos rapazes cumpriam as referidas recomendações.

Além desta plêiade de pesquisas abordando diferenças nas prevalências do cumprimento das recomendações diárias de AFMV, há também uma variedade de estudos que se dedica à investigação das variáveis correlatas da AF diária de crianças e jovens (Ferreira et al., 2007; Gustafson & Rhodes, 2006; Sallis et al., 2000). O propósito tem sido, genericamente, o de identificar sub-conjuntos de variáveis que desempenham papéis importantes na interpretação das diferenças nos níveis de AF das crianças (Armstrong & Welsman, 2006; Crespo et al., 2013; Riddoch et al., 2004; Seabra et al., 2013). Até à data, foram identificados fatores biológicos, familiares, psicológicos, sociais e culturais (Ferreira et al., 2007; Malina et al., 2004; Sallis et al., 2000; Van der Horst et al., 2007), embora nem sempre seja clara a importância relativa de cada um deles. Por exemplo, é recorrente a evidência da influência do sexo nos padrões e níveis de AF, sendo que os rapazes, de um modo geral, são mais ativos (Gustafson & Rhodes, 2006; Hinkley et al., 2008; Van der Horst et al., 2007). Informação recente acerca de comportamentos de saúde em crianças em idade escolar de países da Europa e América do Norte (Healthy Behaviour in School-aged Children – HSBC) relataram que as raparigas, independentemente da faixa etária e país, tendem a ser menos ativas do que

os rapazes. Dados da população portuguesa da HSBC, aos 11 anos de idade, mostram que 14% das raparigas e 23% dos rapazes admitiram envolver-se em AFMV em pelo menos 60 minutos por dia (World Health Organization, 2012). Numa outra direção, é sugerido em três revisões da literatura (Ferreira et al., 2007; Hinkley et al., 2008; Sallis et al., 2000), que o tempo passado ao ar livre, bem como políticas relacionadas com a AF na escola, o acesso a equipamentos e as estruturas de jogo na escola (Davison & Lawson, 2006; Ferreira et al., 2007) estavam positivamente associados aos níveis de AF.

Como as crianças passam parte substancial do seu tempo no contexto físico e social da escola, esta é um espaço de grande importância para a promoção da AF, dado ser o local que permite a participação em diversas formas de AF (estruturada e não-estruturada), tais como atividade lúdico-desportivas informais e não supervisionadas.

Uma outra variável que tem sido estudada como eventual modificadora dos níveis de AF é o estatuto socioeconómico (ESE). Por exemplo, há investigadores que reportam associações positivas entre AF e o ESE (Gustafson & Rhodes, 2006; Micklesfield et al., 2014; Nogueira et al., 2013), enquanto outros mostram inconsistência nos resultados (Ferreira et al., 2007).

Relativamente ao suporte parental na prática de AF dos filhos, a investigação disponível é inconclusiva na indicação do sentido dos resultados. Por exemplo, os estudos de revisão de Ferreira et al. (2007) e Sallis et al. (2000) não encontraram associações de efeito moderado a elevado entre AF e o suporte parental, ao passo que Gustafson & Rhodes (2006) e Van der Horst et al. (2007) observaram associações positivas neste binómio.

Um outro foco de atenção da pesquisa diz respeito ao significado e alcance do ambiente físico. Enquanto algumas revisões da literatura (Davison & Lawson, 2006; Sallis et al., 2000) mostram que a proximidade de parques/*playgrounds*, o acesso a instalações e programas desportivos têm uma relação consistentemente positiva com os níveis de AF, outros autores (Ferreira et al., 2007; Van der Horst et al., 2007) não encontraram associações estatisticamente significativas. É bem provável que esta heterogeneidade de resultados esteja associada aos diferentes modelos de pesquisa, sobretudo

distintos métodos de medição da AF, bem como a diferentes estratégias de amostragem e de tratamento da informação. A utilização de modelos conceituais de vários níveis e o recurso a procedimentos estatísticos relativamente sofisticados podem facilitar este tipo de investigação, esclarecendo melhor alguns aspectos da influência destes fatores (Ding & Gebel, 2012) e, consequentemente, os mecanismos que lhes estão subjacentes.

A AF é um construto complexo, e uma compreensão extensiva dos mecanismos reguladores dos seus níveis e padrões é uma tarefa desafiadora, à semelhança de outras facetas do comportamento humano. Apesar do crescente corpo de conhecimento que suporta os benefícios da AF para a saúde (Andersen et al., 2006; Metzger et al., 2010), a verdade é que é ainda insuficiente o conhecimento disponível acerca dos mecanismos subjacentes aos fatores intimamente relacionados com os níveis e padrões de AF das crianças e jovens.

O Projeto ISCOLE

A amostra alvo desta dissertação provém de um projeto internacional de pesquisa que incluiu 6000 crianças, com idade média de 10 anos, designado ISCOLE (*International Study of Childhood Obesity, Lifestyle and the Environment*). Trata-se de um estudo transversal e multinacional que envolve 12 países (Austrália, Brasil, Canadá, China, Colômbia, Espanha, Finlândia, Índia, Quênia, Portugal, África do Sul, Reino Unido, Estados Unidos) das cinco grandes regiões geográficas do mundo (Europa, África, América, Ásia e Oceania). Cada centro de estudo nacional identificou um ou mais distritos escolares alvo, de forma a obter uma amostra aleatória de 500 alunos em torno de uma média de 10 anos de idade. A amostra final incluiu crianças entre 9-11 anos de idade. A idade foi definida tendo por base a necessidade de controlar para o efeito da maturação biológica os níveis e padrões de AF. Ao selecionar crianças com 10 anos de idade, a probabilidade de encontrar crianças que já iniciaram o seu salto pubertário é diminuta, ainda que tal possa ocorrer nas meninas, já que em média o salto ocorre aos 10 anos.

O centro coordenador do ISCOLE está situado em *Baton Rouge* no *Pennington Biomedical Research Center* (PBRC) da *Louisiana State University*, USA, sendo responsável pela implementação e gestão global do projeto. Cada centro nacional do ISCOLE foi dirigido por um investigador principal, responsável pela implementação do estudo a nível local.

O protocolo incluiu recolha de informação acerca do indivíduo (antropometria, estilo de vida, dieta e atividade física com recurso a acelerometria), envolvimento escolar (questionário administrado aos diretores da escola), família e vizinhança (questionários preenchidos pelos pais). O protocolo de estudo foi desenvolvido no PBRC e implementado em todos os locais de estudo. Um rigoroso sistema de formação e certificação dos avaliadores foi desenvolvido e implementado, incluindo módulos de formação *online* e encontros regionais (incluindo entre 3 e 4 centros nacionais de pesquisa) de formação presencial. Foram realizadas sessões de treino regionais pela equipa do PBRC, antes da recolha de dados, em cada local de estudo. Todos os colaboradores do projeto foram certificados por especialistas treinados para fazer as medições necessárias, o que envolveu a realização de módulos de formação *online*, a visualização de vídeos de protocolo e a conclusão com sucesso de exames *online* antes de iniciar as recolhas de dados.

O protocolo do ISCOLE foi aprovado pelo Centro de Pesquisa Biomédica do *Pennington Institutional Review Board*. Cada protocolo, adaptado para cada local de pesquisa, também foi aprovado pelos conselhos de ética das instituições participantes. Os consentimentos informados dos pais/filho e todos os questionários foram traduzidos para o idioma de cada centro nacional de estudo de acordo com procedimentos aprovados pelas instituições locais.

Para facilitar a inserção e gestão dos dados foi desenvolvido, pelo centro de coordenação e pelo grupo de Sistemas de Informação de Pesquisa da *Wake Forest School of Medicine* (Winston-Salem, Carolina do Norte), uma base de dados *online*, facilitando o fluxo de informações e incrementando o nível de comunicação dentro do ISCOLE.

O Projeto ISCOLE em Portugal

O ISCOLE em Portugal ficou a cargo do Laboratório de Cineantropometria e Estatística Aplicada da Faculdade de Desporto da Universidade do Porto, dirigido pelo Professor Doutor José António Ribeiro Maia. A amostra foi constituída por 777 crianças provenientes de 23 escolas da área do grande Porto, com uma taxa de adesão de 95,7%. As recolhas do vasto leque de informação decorreram entre Setembro de 2011 e Fevereiro de 2013.

Inicialmente foi realizado um levantamento das escolas existentes na região do Grande Porto, a partir da Direção Geral do Norte, seguida de uma escolha aleatória de 23 dessas escolas. De seguida, foi elaborado um plano estratégico relativo aos benefícios do projeto para a comunidade escolar, primeiramente a um Professor de educação física de cada escola, e de seguida a todo o grupo de educação física. Após a obtenção do consentimento do grupo de educação física, o projeto foi apresentado à direção de cada escola. Aprovado o projeto pela direção e conselho pedagógico, o mesmo foi apresentado à associação de pais para haver uma ligação forte com a comunidade escolar. De seguida, foi enviado um consentimento informado para todas as crianças que se encontravam na faixa etária pretendida. Após receção do consentimento informado assinado pelos pais/responsáveis legais, uma amostra equilibrada de rapazes e raparigas foi selecionada, i.e., uma proporção equivalente dos dois sexos em termos de efetivos. Depois do processo de seleção de amostragem, procedeu-se à calendarização das recolhas de dados por escola (uma semana por escola), bem como a preparação de todos os instrumentos de avaliação necessários. O contato com escolas, crianças e encarregados de educação foi permanente, e no final do estudo foi enviado, a cada escola, um relatório detalhado com os principais resultados obtidos, semelhantemente, foi entregue a cada participante um relatório contendo informação sucinta sobre a sua avaliação.

Objetivos

Esta dissertação é percorrida pelos seguintes propósitos:

1. Identificar a importância de variáveis correlatas de natureza biológica, demográfica, social, psicológica e comportamental no cumprimento das orientações da OMS em termos de AFMV diária.

2. Estimar a frequência de crianças portuguesas, com 10 anos de idade, que cumprem as recomendações diárias de AFMV e em quantos dias da semana.

3. Identificar a presença de variabilidade entre escolas no cumprimento das recomendações diárias da AFMV.

4. Estimar o efeito de variáveis do sujeito e do ambiente escolar associado ao cumprimento das recomendações diárias da AFMV.

Estrutura da dissertação

Esta dissertação está estruturada de acordo com o "Modelo Escandinavo" sendo constituída por 4 capítulos referidos na *Tabela 1*. O segundo e terceiro capítulos contêm os artigos redigidos de acordo com as normas e orientações específicas do periódico a que foi ou será submetido. No final cada capítulo apresentam-se as referências bibliográficas.

Tabela 1: Capítulos da dissertação e seus principais objetivos.

Capítulo 1	Introdução geral, a relevância do estudo e os objetivos da pesquisa.
Capítulo 2	**A count model to study correlates of 60 minutes of daily physical activity in Portuguese children** Apresentar dados sobre as crianças portuguesas (com idade entre 9-11 anos) que cumprem as diretrizes da atividade física moderada a vigorosa (AFMV) e identificar a importância relativa de correlatos biológicos, demográficos, sociais, psicológicos, ambientais e comportamentais associados a AFMV diária das

	crianças. *Artigo a submeter ao Pediatric Exercise Science* Autores: Borges A, Gomes TN, Santos DV, Pereira, S, dos Santos FK, Chaves R, Katzmarzyk PT, Maia JAR
Capítulo 3	**Counting the number of days children meet moderate-to-vigorous physical activity. A multilevel modeling analysis** Identificar a presença de variabilidade entre escolas no cumprimento das recomendações diárias da AFMV nas crianças portuguesas, bem como estimar os correlatos, a nível do sujeito e do ambiente escolar, no cumprimento das recomendações diárias da AFMV. *Artigo a submeter ao International Journal of School Health* Autores: Borges A, Gomes TN, Santos DV, Pereira, S, dos Santos FK, Souza M, Katzmarzyk PT, Maia JAR
Capítulo 4	Síntese final e conclusões gerais da Dissertação.

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Capítulo 2

Artigo Original

A count model to study correlates of 60 minutes of daily physical activity in Portuguese children

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Artigo em submissão ao Pediatric Exercise Science

Abstract

This study aimed to present data on Portuguese children (aged 9–11 yrs) complying with moderate-to-vigorous physical activity (MVPA) guidelines, and to identify the importance of correlates from multiple domains associated with meeting the guidelines. Physical activity (PA) was objectively assessed by accelerometry throughout 7-days. A count model using a Poisson distribution was used to identify the best set of correlates that predicts the variability in meeting the guidelines. Only 8.3% of children met the recommended daily 60 minutes of MVPA for all seven days of the week. Further, the Cochrane-Armitage chi-square test indicated a linear and negative trend ($p<0.001$) from none to all 7 days of children complying with the guidelines. The count model explained 17% of the variance in meeting MVPA guidelines daily. Being a girl, having a higher BMI, belonging to families with higher income and increase in time to walking from home to a sporting venue reduce significantly the probability of meeting daily recommended MVPA across the seven days. On the other hand, time spent outside after school increased the probability of meeting MVPA guidelines by 6.5%.

Introduction

Despite some controversy about a putative decline on children's physical activity (PA) during the last decades (13, 16) it is generally accepted that children around the globe are currently failing to meet the World Health Organization (WHO) PA guidelines (49). According to Strong et al. (41) and WHO recommendations, children and youth aged 5–17 yrs should accumulate at least 60 minutes of moderate-to-vigorous physical activity (MVPA) on a daily basis in order to enjoy health benefits (49). These recommendations are believed to prevent the development of chronic disease risk factors during childhood (4), which have been shown to track from childhood into adulthood (3).

Previous studies have reported mixed results with respect to the proportion of children complying with the recommended guidelines of at least 60 minutes of MVPA per day, which have ranged from 5% to 97% (11, 25, 33). This large variation has been attributed to specific characteristics of the population studied, such as culture and demographics, as well as to different analysis procedures.

A comprehensive investigation of variation among children's daily physical activity has identified a broad spectrum of correlates (20, 36). Three review papers (20, 22, 36) identified sub-sets of variables that play important roles in explaining differences in children's PA levels; in addition, mixed results have been reported in terms of correlations (magnitude and direction) and regression coefficients. Furthermore, distinct conceptual models and diversified

statistical approaches have been used to investigate the existing relationships between PA levels and patterns and their recognized covariates (5, 19)

A commonly used research template is the ecological model of four domains of active living (34) in which PA behavior is based, to some extent, on intra-personal, familial, social, cultural, environmental and policy characteristics. For instance, socioeconomic factors (29), distance to sports facilities (26) and time spent outdoors (20) have been shown to be predictors of physical activity habits during childhood. As such, in this study, we applied a Poisson regression model, aiming to identify the importance of biological, demographic, social, psychological, environmental and behavioral correlates in Portuguese children attaining MVPA recommendations. Previous to this model fitting process, data on the frequency of children attaining the MVPA recommendations will be presented.

Material and Methods

Sample

This study is part of the International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE), a multi-national investigation aiming to determine the relationships between lifestyle behaviors and obesity using the ecological approach as a research template (24). The sample comprises 777 5th grade Portuguese children aged 9–11 yrs (358 boys and 419 girls) that were selected from 23 schools, in a two-stage sampling schema. All 5th grade children were invited to participate in ISCOLE, but only those between 9.5 and

10.5 yrs were selected. These were randomly selected so that 30 to 40 children from each school, 50% of each sex, were chosen and compliance rate was 95.7%. Written consent was obtained from all parents and school directors. Further, this project was generally approved by the Pennington Biomedical Research Center Institutional Review Board and locally by the Ethics Committee of the University of Porto. Data quality control was systematically assessed and certified by the ISCOLE Coordinating Center(24).

Anthropometry

Height, weight and body fat were measured according to standardized ISCOLE procedures (24). Each child was measured twice, and if there was a discrepancy between the two measurements beyond the tolerated error, a third measure was taken. For the present analysis the mean value of each measurement was used. Body mass index (BMI) was computed using the standard formula [weight(kg)/height(m)^2], and WHO cut points (7) were used to classify children as normal weight, overweight or obese.

Maturity Offset

Biological maturation was estimated with the maturity offset procedure proposed by Mirwald et al. (28). This procedure estimates the timing of occurrence of peak height velocity (PHV), computing the distance each subject is from PHV and expresses it in decimal years. A positive (+) maturity offset represents the number of years a child is beyond PHV, whereas a negative (–) maturity offset represents the number of years he or she is before PHV.

Physical Activity

Children's PA was objectively measured with the Actigraph GT3X+ accelerometer. The accelerometer was worn at the waist on an elasticized belt on the right mid-axillary line. ISCOLE children were encouraged to wear the accelerometer 24 hours per day for at least 7 days (plus an initial familiarization day and the morning of the final day), including weekend days. The minimal amount of accelerometer data that was considered acceptable for inclusion in the ISCOLE sample was 4 days with at least 10 hours of wear time per day, including at least one weekend day. However, the present analysis is further restricted to those children with 7 days of data.

For the purpose of this study our dependent variable comprises the number of days during a whole week that each child attains 60 min of MVPA. MVPA was defined as all activities greater than 574 counts per 15 seconds (17). Since we have missing data on several children in some of the days, the final sample with complete data on the seven days comprises 582 children. No statistically significant ($p<0.05$) differences in biological and environmental variables were found between those who have missing information, whose pattern is missing at random, from those who have complete data.

Neighborhood and home environment questionnaire

A questionnaire about the neighborhood and home environments was completed by all parents (26). The questionnaire provides information on basic demographics, ethnicity, family health, socioeconomic factors, the home social

environment, the home and neighborhood physical activity environment and neighborhood built environment. For the present study, neighborhood and home environment variables used included: family annual income, social factors (if the family provides transport to a place where the child can do physical activity; if the parents encourage their child to do physical activity), and neighborhood context (distances from home to physical activity places: for example, an sport venue (indoor recreation or exercise facility), bike or walking trails, playing fields/courts, public parks or playgrounds).

Lifestyle questionnaire

A questionnaire including behavioral and psychological information about sleep time, screen time, time spent on activities outside the home and children's perceived parental support was completed by all children (26). Screen time was computed based on the child-reported time spent watching television, playing non-active video games or using the computer for leisure on weekdays and weekend days. The number of children fulfilling the recommendations of less than two hours of screen time/day (1) was also calculated.

Statistical analysis

Exploratory data analysis and descriptive statistics were performed in SPSS 21. Since our dependent variable comprises the number of days during a whole week that each child attains 60 min of MVPA, which in itself is a count, a Poisson regression model was used (10, 27, 40) as implemented in NCSS9 software (32) following the classical text of Cameron & Trivedi (9). Further, a

search technique (Forward selection with switching) implemented in the NCSS9 software (NCSS9 Manual p. 325-5) was used to find the smallest subset of the available regressor variables that does a good job of predicting the number of days in which the child meets MVPA guidelines. These analyses were conducted in NCSS 9 (23). The Cochrane-Armitage chi-square test, implemented in PEPI 4.0 (2) software, was used to identify a trend in MVPA 60 min counts (from never=0 to everyday=7).

Results

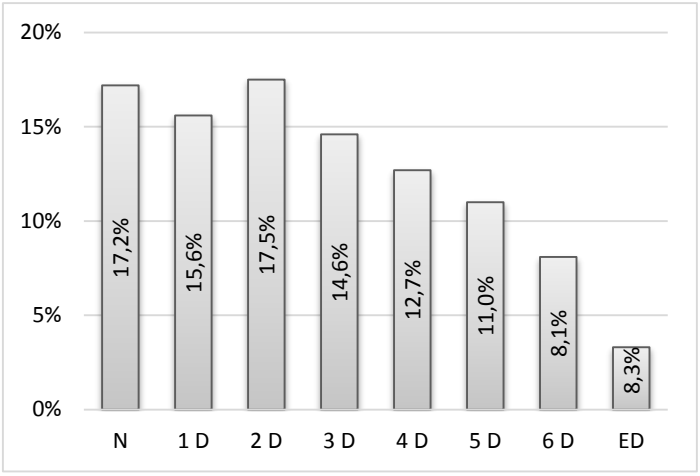
Table 1 presents the sample means and standard deviations for relevant variables by sex. On average, children are still to experience their PHV as the maturity offset is -1.88±0.89. Further, no significant differences were found between boys' and girls' weight (t=-0.39, p=0.698), height (t=-0.04, p=0.971) and BMI (t=-0.58, p=0.562), but girls were closer to their predicted PHV than boys (p<0.001).

Only 8.3% of children meet the recommendation of daily 60 minutes of MVPA for seven days of the week, and 17.2% fail to meet this recommendation on any of the seven days (Figure 1). Further, the Cochrane-Armitage chi-square test indicated a linear and negative trend (p<0.001) from none to 7 days of children complying with the 60 minutes guideline.

Table 1: Boys´ and girls´ descriptive statistics (means±standard deviations), t and p-values for testing sex differences.

	Boys M±SD	**Girls M±SD**	**t**	**p-value**	**Total M±SD**
Height (cm)	143.4 ± 6.6	143.3 ± 7.0	0.26	0.792	143.3 ± 6.8
Weight (kg)	40.1 ± 9.3	39.9 ± 9.3	0.27	0.785	40.0 ± 9.3
BMI ($kg \cdot m^{-2}$)	19.4 ± 3.5	19.3 ± 3.3	0.28	0.777	19.3 ± 3.4
Maturity offset	-2.75 ± 0.44	-1.25 ± 0.52	-37.31	<0.001	-1.88±0.89

Figure 1: Percentage of children meeting the 60 min of MVPA guidelines



(N=Never,1D=1 Day, 2D=2 Days, 3D=3 Days, 4D=4 Days, 5D=5Days, 6D=6Days, ED=Every Day)

Table 2 presents data on biological, demographic, social, psychological, environmental and behavioral variables associated with PA during childhood. Most families (78.8%) had an annual income ≤ €23.999; 47.6% of children reported to be encouraged by parents to practice PA every day, whereas only 6% reported no support at all. However, only 12.1% of the children are driven to PA facilities every day. Further, 29% of our sample reported to completely agree with the possibility of asking parents to practice PA with them.

Most children spend a maximum of 20 min walking from their home to sports facilities, and most parents (81.5%) do not agree with the assertion that there is a high crime rate in the neighbourhood. Nevertheless, the vast majority of the children (93%) do not spend more than two hours in activities outside home during weekdays after school. During the weekend this value decreases to 76.5%.

Seventy five percent of the children met the recommendations of no more than two hours of screen time per day, whereas during the weekend only 38.3% met the recommendations. As for sleep time, children reported to have slept, on average, 577 and 628 minutes per day, during weekdays and weekend days, respectively.

Table 2: Summary information regarding biological, demographic, social, psychological, environmental and behavioral variables

	Frequency (%) or Mean
Annual Income	
≤€ 23,999(0)	78.8
≥€ 24,000(1)	21.2
Family Support	
Encourage	
Never(0)	6.0
1-2 Days(1)	25.9
3-4 Days(2)	16.7
5-6 Days(3)	4.0
Every Day(4)	47.4
Provide Transport	
Never(0)	25.0
1-2 Days(1)	40.3
3-4 Days(2)	17.1
5-6 Days(3)	5.6
Every Day(4)	12.1
I can ask my parent do physically active things with me	
Disagree a lot(0)	13.4
Disagree a little(1)	13.4
Disagree/Agree(2)	22.5

Agree a little(3)	21.6
Agree a lot(4)	29.0
Time to walk from home to…	
Indoor recreation	
1-5 min(0)	13.6
6-10 min(1)	22.8
11-20 min(2)	22.6
21-30 min(3)	13.3
21-30 min(4)	13.1
Don't Know(5)	14.6
Bike/ /walking trail	
1-5 min(0)	14.5
6-10 min(1)	13.9
11-20 min(2)	14.3
21-30 min(3)	8.5
21-30 min(4)	18.9
Don't Know(5)	29.9
Playing fields/courts	
1-5 min(0)	12.2
6-10 min(1)	15.7
11-20 min(2)	22.2
21-30 min(3)	11.2
21-30 min(4)	14.5
Don't Know(5)	24.2
Public Parks	
1-5 min(0)	11.6
6-10 min(1)	20.5
11-20 min(2)	22.6
21-30 min(3)	11.0
21-30 min(4)	18.3
Don't Know(5)	16.0
There is a high crime rate in neighborhood	
Strongly disagree(0)	48.5
Somewhat disagree(1)	33.0
Somewhat agree(2)	13.3
Strongly agree(3)	5.2
Time Spent Outside	
Week days	
< 1 hour(0)	40.1
1 hour(1)	32.2
2 hours(2)	20.7
3 hours(3)	5.5
4 hours(4)	0.5
5 or more(5)	1.0
Week-end	
< 1 hour(0)	31.5

1 hour(1)	23.1
2 hours(2)	21.9
3 hours(3)	12.4
4 hours(4)	4.6
5 or more(5)	6.5
Screen Time	
Week days	
≤ 2 hours	75.1
> 2 hours	24.9
Sleep Time [minutes (M±SD)]	
Week days	576.5±51.3
Weekend Days	628.1±101.2

Table 3 shows the Poisson regression results for the best subset selection using the Forward covariate selection. The model Pseudo-R^2 (explained variance) was 17%, and from the 12 putative covariates (see Table 2), only five were statistically significant and entered the final model. Given that the Beta coefficients are maximum likelihood estimates and difficult to interpret, their exponentiated values are expressed as Rate Ratios (RR) which makes them easier to understand. Being a girl reduces the chances of complying of the 60 min MVPA guidelines by ≈50%, and children with higher BMI have a lower expectation of increases in the number of days complying with the recommendations, and the same occurs to those belonging to families with higher income (a reduction of ≈6.9%). For each category increase in time to walk from home to a sporting location an expected decrease (4.2%) in the number of MVPA counts across the seven days was found. Children with a higher category of time spent outside after the school multiply the expected number of complying days by 1.065 or increases it by 6.5%.

Table 3: Poisson regression coefficients, standard errors (se), p-values, Rate Ratios (RR) and corresponding 95% confidence intervals (95%CI)

Variables	Beta (se)	p-value	RR	95% RR CI
Intercept	2.474(0.211)	<0.001	11.687	7.840 to 17.962
Sex	-0.617(0.016)	<0.001	0.546	0.486 to 0.613
BMI	-0.021(0.009)	0.023	0.979	0.961 to 0.997
TWSL	-0.042(0.018)	0.024	0.958	0.924 to 0.994
AHI	0.067(0.015)	<0.001	0.935	0.907 to 0.964
TSO	0.063(0.029)	0.034	1.065	1.004 to 1.129

TWSL= Time to walk from home to a sporting location; AHI=Annual household income; TSO= time spent outside after school

Discussion

Several studies have reported the prevalence of meeting PA guidelines in children and adolescents (5, 16, 19). For example, Telford et al. (45) investigated MVPA patterns over a week and reported that overall, 31% of boys and 16% of girls met MVPA recommendations in a longitudinal study of Australian children aged 8-12 yrs. Further, Baptista et al. (6) in a study of four consecutive days with accelerometers found that, on average, 36% of Portuguese youth aged 10–11 yrs (boys=51.6%, girls=22.5%) were considered sufficiently active using the 60 $min \cdot d^{-1}$ of MVPA guidelines.. On the contrary, data from seven European countries including Belgium, Greece, Hungary, the Netherlands, Norway, Slovenia and Spain showed that only 4.6% of the girls and 16.8% of the boys met the recommendations (48). This set of results contrasts with those from our sample in which only 8.3% of all children met, in all seven days of the week, the daily MVPA recommendations, and 17.2% do not attain these recommendations on any of the seven days (but see Figure 1). Several factors including population and sampling differences, MVPA definition and data processing protocols are likely contributors to the differences found

across studies. Furthermore, the existence of different intensity-related cut points for children and adolescents PA has hindered research efforts to quantify, understand, and intervene on physical activity behavior (47). For example, only the Telford et al. (45) study used the same MVPA cut off point during the 7 days as we did, and the differences found between Australian and Portuguese children may be attributable to cultural and behavioral differences.

When investigating children´s PA patterns there is a tendency to compare weekdays and weekend days (18, 32, 45). For instance, Telford et al. (45) concluded that in Australian children Friday (Boys=39%, Girls=21%) and Sunday (Boys=16%, Girls=10%) were the highest and lowest compliant days of the week, respectively, for meeting recommendations. Ramirez et al (32), using the same cut-off point of our study showed that 26.6 and 24.5% of Liverpool (England) youths and 26.0 and 27.1% of Madrid (Spain) youths achieved recommended levels of MVPA on week days and weekend days, respectively. In our case, the most compliant day was Friday (boys=59%, girls=36.5%), and the least was Sunday (boys=26.9%, girls=15%). Further, we identified a linear negative trend in compliance from one to seven days, which can be compared to the Crespo et al. (11) study in which, on average, children achieved 59 ± 23 minutes of MVPA per day across all 7 days. However, when Crespo´s et al (11) daily MPVA data were individually tabulated, only 24 children (21%) engaged in ≥ 60 minutes of MVPA on at least 5 days, and only 6 children (5%) achieved ≥ 60 minutes of MVPA on all 7 days.

It has been postulated that environmental characteristics play important roles in governing children's daily PA levels and patterns (20). As such, it is

important to consider a comprehensive set of these correlates which are believed to explain variation in children's MVPA (36). Our model explained 17% of the total variance in meeting MVPA guidelines, but only five correlates (sex, BMI, time to walk from home to a sporting location, annual household income and time spent outside after school) were statistically significant. As expected, sex was a significant predictor of MVPA, and being a girl reduces the chances of attaining the guidelines by approximately 50%. This result is in line with previous reports (18) that concluded that sex was the most significant correlate of MVPA. A possible explanation for this result is that boys and girls engage in different types of activities with marked intensity differences (39). For example, Blatchford et al. (8) showed that during school hours boys are more likely to engage in ball games and vigorous activities, whereas girls are more prone to engage in quieter games without much physical contact. Another possible explanation might be attributable to maturational status. Thompson et al. (46) showed that as girls mature earlier than boys, and as PA tends to decrease with maturity, this might explain sex differences. Still, in our data, maturity was not a significant MVPA predictor and which may be related to the narrow age range of the sample (9 to 11 years).

Higher BMI was found to be negatively associated with the number of days children complied with MVPA recommendations, which is a consistent with previous studies (50). For example, Bergh et al. (7) studying 1,129 Norwegian 11 year old children found that those with normal weight scored higher on percentage daily MVPA than overweight/obese children. Yet it is not always easy to clarify if having a high BMI leads children to be less physically active or

is it the other way around, i.e., do less active children has a tendency to become more heavy (14). It has been observed that obese children, whom are less active, also present poorer motor skill proficiency as compared to their normal weight peers (30), lower physical competence perception and success as well as a lower peer acceptability in games and sports (39).

In our sample, being part of a higher income family reduces the chances of attaining the guidelines by ≈ 6.9%. Nogueira et al. (29) studied the associations between children obesity, sports activity, and perceived environmental characteristics with children's SES and found that low and medium SES children were more likely to be obese and less likely to participate in sports activity than their high-SES peers. This result seems to be in disagreement with ours. However, it has been suggested (42) that lower income neighbourhoods provide a greater amount of government funded opportunities for PA when compared to higher income neighbourhoods.. And also, it needs to be acknowledged that sports activity is only one facet overall physical activity, which may contribute to further explain this discrepancy.

For each category increase in walking time from home to a sporting venue, a 4.2% decrease in the prevalence of children complying with MVPA guidelines is observed which is in line with previous research (31, 43). In a recent review, Oliveira et al. (31) found a significant positive association between proximity to parks and playgrounds and children's PA. Further, Tappe et al. (43) examined the association between parent reports of their neighbourhood environment and children's activity within the neighbourhood and in parks, and concluded that parent-reported proximity to play areas

correlated positively with accelerometry outcomes. One of the factors that may explain this observation is active transportation, i.e., children walk to places that are closer to their homes to engage in diversified PA. With increasing distances either two behaviors are likely to occur: (i) children prefer not to practice PA in these places or; (44) children are forced to use other means of transportation (35).

When analyzing the results for BMI, income and walking time from home to a sport venue, we may hypothesize that, in a way, there is a relationship between these three variables. An argument could be raised that annual income has a major influence on active transportation to sports facilities, as the higher the annual income the greater availability of cars for transportation, leading to diminished levels of physical activity, which in turn promotes BMI increases.

In the present sample, spending time outside after school increased the probability of meeting the guidelines by each additional day by 6.5%. Ferreira et al. (20) conducted a systematic semi-quantitative review of 150 studies on environmental correlates of PA in children, and time spent outdoors was consistently associated with higher levels of PA. Another systematic review on the assessment of “physical activity environmental factors” (36) identified access to sports facilities and programmes, and time spent outdoors as being consistently associated with children's PA. One of the reasons that has been suggested to explain this finding is that children would be exposed to stimuli and/or opportunities to be active and engage in unstructured PA while they are outside as compared to inside (37).

Unlike other studies, we did not find statistical significance for environmental variables such as the presence of sidewalks (12) and cul de sacs as well as security in the area of residence (43). Crime is a frequently cited barrier to physical activity, but its association has been shown to be inconsistent (21) as people from different countries and cultures may have different safety perceptions and may cope with unsafe neighbourhoods differently.

Notwithstanding the significance of the present findings, some limitations must be addressed. Firstly, restricting the sample to the Porto urban area limits the generalization of results in terms of the Portuguese population. Yet, a comparison of the present sample characteristics with available information from the Portuguese population of the same age and sex was done. For example, in data not shown here, no differences were found in the prevalence of overweight/obesity (38), as well as in the percentage of children attaining sufficient levels of PA (6). Secondly, we must bear in mind that we used Evenson cut-off points that have been proven widely acceptable in MVPA classification accuracy (47), although the cut-off issue continues to be an unsolved matter. Lastly, limiting our sample age to 10 years may be a restrictive factor, although it marks the beginning of a very important transition phase from late childhood to adolescence (15) and a significant change in school habits. On the other hand, the present study has several strong points. Firstly, the high quality data set which is a part of an international study with unparalleled information as shown by Katzmarzyk et al (24). Secondly, the usage of objective PA measurement during 7 consecutive days with a substantial time frame, allows for a high degree of consistency to detect levels of daily physical

activity over a week. Thirdly, the broad spectrum of environmental variables makes them unique in a single study.

In conclusion, the present results show that the percentage of children meeting the 60 minutes of daily MVPA recommendations, seven days a week, is very low. Further, there is a linear negative trend in the compliance to the MVPA guidelines from one to seven days. In addition, the number of complying days with MVPA guidelines is positively associated with sex, BMI, family income, walking time from home to a sporting venue, and time spent away from home after school. More efforts are needed to uncover the relevancy of different environmental correlates on meeting PA recommendations. These results emphasize the importance of taking into account multiple levels of influence when developing interventions to promote healthy and active lifestyles.

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Capítulo 3

Artigo Original

Counting the number of days children meet moderate-to-vigorous physical activity. A multilevel modeling analysis

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Abstract

BACKGROUND: Children spend most of their awake time at school. Further, school plays a vital role on educating and promoting children healthy behaviors, namely their physical activity levels. This study aimed to investigate the association between individual and school characteristics with the number of days children comply with the recommended 60 daily minutes of moderate-to-vigorous physical activity (MVPA).

METHODS: Sample size comprises 582 Portuguese children, aged 9–11 years, from 23 schools. Height and weight were measured and BMI calculated. Sleep time and MVPA were measured by accelerometry, and biological maturation was estimated. School characteristics were assessed. Maximum likelihood estimates of model parameters were obtained via the multilevel analysis with children as level-1, and school context as level-2 data.

RESULTS: Girls are less likely to comply with daily MVPA as well as those who are overweight/obese children, more sedentary, sleep less than 10 hours·day^{-1}, and use active transportation to school. The number of sports facilities and greater sports activities at school are not always positively linked with children compliance with MVPA guidelines.

CONCLUSIONS: Individual and school features are differently associated with children compliance with daily MVPA recommendations. These results should be taking into account in the implementation of school policies and practises, leading to a more efficient promotion of healthy lifestyles in children, namely in the increase of their daily MVPA.

Introduction

Adult moderate-to-vigorous physical activity (MVPA) levels have consistently been associated with a reduction in obesity and cardiometabolic risk factors [1]. This evidence holds also true during childhood and adolescence, and walks alongside the known fact that healthy behaviors track from childhood through adolescence into adulthood [2-4].

It is now well established that a PA positive impact on health, is generally dependent upon a daily amount of 60 minutes of MVPA [5, 6]. Although available research concerning youth compliance with this amount is increasingly available across different countries [7-9], main data analysis axes around mean daily minutes from the total number of assessment days, and not with the PA compliance variability along a whole week [10, 11]. MVPA variability during seven consecutive days has been previously studied [12] and a consistent daily pattern of MVPA, characterized by a gradual build-up of daily PA through the school-days followed by a progressive decline during the weekend was reported. This suggests that children compliance with recommended daily PA guidelines varies according to the day of the week, and can be influenced by individual traits as well as by school characteristics. Furthermore, these authors strongly pointed-out that in order to gain a more precise understanding of MVPA variability along a whole week it would be necessary to consider seven days and the frequency with which children meet the guidelines [13].

As children spend most of their awake time at school, its environment is expected to promote MVPA in a varied set of education activities which are decisive to their adequate motor development, healthy habits acquisition as well as in the prevention of obesity [14, 15]. Available research concerning differences between school characteristics (eg., number of students, available equipment, different sports offer, policies related to PA practice) and their association with children's PA, reported conflicting results [but see Ferreira et al. [16]]. For example, in a review study, Davison & Lawson [17] found that the availability of equipment and permanent activity structures in school play areas were associated with higher PA levels. Similarly, a study in Norway comparing PA levels of children from schools with distinct number of outdoor facilities found

that boys and girls from schools with greater outdoor facilities were 2.69 and 2.90 times more likely to be physically active, respectively [18]. Differently, van Sluijs et al. [19] investigated school environmental factors that promote or inhibit PA, and found that having a written or informal policy for PA was negatively associated with time spent in vigorous activity.

Notwithstanding available data concerning Portuguese children daily MVPA [20, 21], it has recently been suggested that 36% of 10-11 year old children complied, on average, with the daily recommendations [9]. Further, the participation in extra-curricular sports has been shown to increase the likelihood of achieving the recommended PA guidelines [22]. Yet, so far no Portuguese studies investigated if the school context can influence the number of days children fulfill the recommended 60 minutes of MVPA, over a week, using a multilevel approach as a suitable statistical tool to address the multiple possibilities imbibed in correlates arising from different contexts [23]. Considering the ecological model as a suitable research template [24], this study aims to identify student (personal) and school (environmental) correlates in the number of week days children comply with MVPA recommendations, by means of the multilevel modeling methodology.

Sample

The sample of this study is part of the International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE), which is a research project conducted in 12 countries from all major world regions [25]. The Portuguese ISCOLE sample comprises 777 5th grade Portuguese children, aged 9–11 yrs (358 boys and 419 girls), from 23 schools of the Northern region of Portugal. These were randomly selected and 30 to 40 children from each school took part in the research; 50% of each sex was chosen, and the response rate was 95.7%. All parents or legal guardians provided written consent for their child to take part in the study and data were collected from September 2011 to February 2013. Further, this project was generally approved by the Pennington Biomedical Research Center Institutional Review Board and locally by the Ethics Committee of the University of Porto, as well as by the schools' directorate councils. Data quality control was systematically assessed and certified by the ISCOLE Coordinating Center.

Level-1 data

Anthropometry

Height, sitting height, weight and body fat were measured according to standardized ISCOLE procedures [25]. Each child was measured twice, and if there was a discrepancy between the two measurements beyond the tolerated error (0.5 cm for height and sitting height, and 0.5 kg for weight), a third measure was taken. For the present analysis, the mean value of each measurement was used. Body mass index (BMI) was computed using the standard formula [weight(kg)/height(m)^2], and the World Health Organization (WHO) cut points [26] were used to classify children as normal weight, overweight or obese.

Biological maturation

Biological maturation was estimated with the maturity offset procedure proposed by Mirwald et al. [27]. This procedure estimates the timing of occurrence of peak height velocity (PHV), computing the distance each subject is from PHV and expresses it in decimal years. A positive (+) maturity offset represents the number of years a child is beyond PHV, whereas a negative (–) maturity offset represents the number of years he or she is before PHV.

Transportation

To assess students' transportation to school, children answered the question: "During the last week you were in school, the main part of your journey to school was by: 1=walking; 2=bicycle, roller blade, skateboard or scooter; 3=bus, train, tram, underground, or boat; 4=car, motorcycle, or moped; 5=other. This information was obtained from the "diet and lifestyle questionnaire" [25], and was coded as 0 if response was from 3 to 5, and 1 otherwise.

Socioeconomic Status

A questionnaire about demographic and family health history containing information about basic demographics, ethnicity, family health and

socioeconomic factors was completed by all parents [25]. For the present study we used information about family annual income, which was classified in 2 categories coded as 0 if the annual income was ≤ € 23,999, and 1 otherwise (≥ € 24,000).

Physical Activity and Sleep Time

Children PA was objectively measured with the Actigraph GT3X+ accelerometer (ActiGraph, LLC, Pensacola, USA). All were instructed how to wear the accelerometer, which was attached by an elastic waistband on the right hip, and should be used 24 hours per day, for at least 7 days (including weekend days), and only be removed for swimming or other aquatic activities.

MVPA was defined as all activities greater than 574 counts per 15 seconds, and sedentary time as <100 counts per minute [28]. Days of accelerometer data were included if there were 10 or more hours of activity for at least 4 days, including at least one weekend day. However, in the present study, only children with 7 valid days were included in the analysis. After this exclusion, the final sample with completed data on the seven days comprises 582 children (335 girls, 247 boys). No statistically significant ($p<0.05$) differences in biological and environmental variables were found between those who have missing information, whose pattern is missing at random, from those included in the analysis.

For this study, the number of days each child complies with the 60 min•day^{-1} of MVPA was counted, ranging from 0 (child does not meet the MVPA daily guidelines any day of the week) to 7 (child meets the MVPA guidelines all days in the week). As such, this outcome variable is a count expressing a number of discrete occurrences which has a Poisson distribution [32].

Sleep time was estimated from average week time (expressed in hours) as proposed by Tudor-Locke et al. [29] and Barreira et al. (under review) where sleep period time is expressed in terms of nocturnal sleep, the beginning of a sleep period was identified as the first 5 consecutive minutes of sleep, and the end of a sleep period was identified as the first 10 or 20 consecutive minutes of wake time, so that, a sleep period was only identified when at least 160 minutes had elapsed between bedtime and wake time. Then, children were categorized

according to the fulfillment, or not, of the daily recommendation for sleep time (<10 h·night^{-1}; ≥10 h·night^{-1}) proposed by the National Sleep Foundation [30].

Level-2 data

School Environment

The school environment information was obtained from a questionnaire completed by the physical education teacher or the school principal [25]. The questionnaire includes items related to school facilities, healthy eating and PA policies, extracurricular activities, frequency of physical education classes and breaks (recess), promotion of active transportation, and the availability of healthy and unhealthy foods in the cafeteria and vending machines. For the purposes of the present study, we considered the following: school size (number of students) divided into tertiles and dummy coded (0 ≤ 632, 1 = 633 to 943, and 2 > 943); number of intramural and interschool PA/sports were divided in three categories (0 = zero to four, 1 = five to eight, 2 = 9 or more), and dummy coded; the presence (i.e., number) of distinct facilities available during school hours which was binary coded (0= zero to four; 1= five or more); and the existence (coded as 1), or not (coded as 0), of written policies and/or practices concerning PA.

Data analysis

Basic descriptive statistics are presented. Differences between boys' and girls' frequencies were tested with a Chi-square test using WinPepi software version 11.39 [31]. As our dependent variable is a count (a number of discrete occurrences), i.e., counting the number of days a child meet with the daily recommendations of 60 minutes of MVPA, we used a Poisson distribution [32]. Given the nature of the clustered data, students nested within schools, a multilevel count model implemented in SuperMix software [33] was used. Based on a iterative procedure all parameters (fixed and random) are simultaneously estimated using a maximum likelihood approach [34, 35]. Further, we allowed the intercept to be random as previously suggested [36]. Individual (level-1) covariates include sex, BMI (coded as 0=normal weight; 1=overweight/obese), SES, maturity offset, sleep time, and sedentary time (centered at the grand

mean); school (level-2) covariates include school size, the number of sports intramural and interschool PA programs, the presence of distinct facilities available during school hours and the existence of written policies or practices concerning PA. As previously mentioned, predictors are in their original metric, binary or dummy coded. Our modeling approach consisted of two steps: firstly we fitted a level-1 model (Model 1) with children characteristics; secondly, and using only the significant predictors of the previous model, we added the school (level-2) predictors (Model 2). Significance level was set at 5%.

Results

Table 1 shows children (level-1) descriptive statistics. Only 8.3% of the total sample complied with the recommendations all seven days of week, as boys (6.9%) complied systematically more than girls (0.6%). There is a high frequency of obese children (27.3%), with boys (33.6%) being significantly (p=0.039) more obese than girls (22.7%). A similar pattern occurs when considering the added effect of overweight and obesity. Most children (73.1%) do not use active transportation to school. Further, 94.8% do not fulfill the recommendations of 10 hours or more of daily sleep. Most families (78.8%) have an annual income of ≤ €23.999.

Table 1 Children descriptive statistics (Level-1 predictors) and p-values associated to the Chi-square test for differences in frequencies

	Total% (N)	girls% (n)	boys% (n)	p-value
Meeting the MVPA guidelines				
0 days	17.2 (100)	23.6 (79)	8.5 (21)	<0.001
1 day	15.6 (91)	21.5 (72)	7.7 (19)	<0.001
2 days	17.5 (102)	21.8 (73)	11.7 (29)	0.002
3 days	14.6 (85)	13.7 (46)	15.8 (39)	0.487
4 days	12.7 (74)	10.7 (36)	15.4 (38)	0.097
5 days	11.0 (64)	4.8 (16)	19.4 (48)	<0.001
6 days	8.1 (47)	3.3 (11)	14.6 (36)	<0.001
Every day	8.3 (19)	0.6 (2)	6.9 (17)	<0.001
BMI status				
Normal weight	56.4 (328)	60.0 (201)	51.4 (127)	<0.001
Overweight	16.3 (95)	17.3 (58)	15.0 (37)	0.452
Obese	27.3 (159)	22.7 (76)	33.6 (83)	0.003
Overweight and Obese	43.6 (254)	40.0 (134)	48.6 (120)	0.039
SES				

≤€ 23,999	78.8 (368)	76.9 (203)	81.3 (165)	0.250
≥€ 24,000	21.2 (99)	23.1 (61)	18.7 (38)	
Transportation to school				
Yes	26.9 (156)	25.7 (86)	28.3 (70)	0.486
No	73.1 (425)	74.3 (248)	71.7 (177)	
Sleep time				
<10 h/day	94.8 (552)	95.5 (320)	93.9 (232)	0.390
≥10 h/day	5.2 (30)	4.5 (15)	6.1 (15)	

Table 2 shows frequencies of distinct school characteristics. As expected, the number of students is fairly spread across schools of varied sizes; the majority offered a diversity (more than five) of intramural or interschool sports (69.5%) and has policies or practices related to PA (91.3%). In addition, 65.2% has less than five different sports offered as intramural and interschool PA programs.

Table 2 School level variables (Level-2)

	School Level (%)
Number of students	
≤632	39.1
633-943	30.4
>943	30.4
Number of sports offered in PE programs	
0 to 4	30.4
5 to 8	56.5
9 or more	13.0
School sports/physical activity related facilities	
0 to 4	65.2
5 or more	34.8
Policies or practices related to physical activity	
Yes	91.3
No	8.7

Multilevel modelling results of the two-step approach are shown on Table 3. Model 1, including children level covariates, shows that all, but SES, are statistically significant ($p<0.05$). On average, boys comply more with the 60 minutes of daily MVPA recommendations than girls; children classified as overweight/obese, who are more sedentary, and with more frequent active transportation comply less; those who sleep more and are more mature comply more. Since these coefficients are on a log scale, a suitable interpretation is to

present their exponentiated values as Event Rates [33]. For example, the intercept=$b^{0.775}$=2.170 corresponds to a girl´s average number of complying MVPA days during a week. Boys comply approximately 2.3 times more (on average they comply ≈5 days per week). Overweight and obese children have 16% less chance to comply, and those who are more sedentary comply less. More mature children have an increased 22% chance to comply, and those who sleep more have an increased rate of 61%. On the contrary, those who are more prone to active transportation have a reduction in their compliance of about 26%.

In model 2, with the inclusion of school level covariates, the individual level covariates retain their importance and meaning (note that we excluded SES because it was not statistically significant). Further, only two of the four school predictors showed a negative association with children compliance with daily MVPA recommendations. Increasing the number of facilities as well as increasing the number, 9 or more, sports offered in interschool or intramural athletics programs by schools, leads to a decrease in the number of schoolchildren who achieve daily MVPA guidelines.

Table 3: Multilevel modeling results

Parameters	Model 1			Model 2		
	β (se)	p-value	Event Rates	β (se)	p-value	Event Rates
Fixed effects						
Children level						
Intercept	0.775 (0.177)	<0.001	2.170	0.872 (0.188)	<0.001	2.391
Sex	0.830 (0.120)	<0.001	2.293	0.764 (0.109)	<0.001	2.148
BMI	-0.181 (0.067)	0.007	0.834	-0.149 (0.061)	0.014	0.862
Sedentary Time	-0.005 (0.001)	<0.001	0.995	-0.005 (0.000)	<0.001	0.995
Maturity Offset	0.201 (0.069)	0.004	1.222	0.152 (0.063)	0.015	1.164
SES	-0.015 (0.074)	0.844	0.986	-	-	-
Sleep	0.480 (0.135)	0.004	1.614	0.531 (0.123)	<0.001	1.701
Transport (active vs passive)	-0.305 (0.061)	<0.001	0.737	-0.256 (0.055)	<0.001	0.774
School level						
Students D1*				0.002 (0.070)	0.974	1.002
Students D2*				0.015 (0.079)	0.850	1.015
Policies PA				-0.185 (0.099)	0.063	0.832
Equipment				-0.186 (0.063)	0.003	0.830
Sports D1§				-0.024 (0.067)	0.717	0.976
Sports D2§				-0.229 (0.104)	0.027	0.796
Random effects						
Intercept	0.029 (0.014)			0.003 (0.005)		
-2LogLikelihood	1713.31			2110.31		

*Dummy coding for school size: nº of students ≤632=reference; nº of students from 633 to 943=D1; nº of students >943=D2.
§Dummy coding for sports offered: 0 to 4=reference; 5 to 8=Dummy 1; ≥9=dummy 2.

Discussion

This study aimed to identity student and school level correlates linked to the number of the days, in a whole week, children comply with MVPA recommendations. Given the data dependency, a multilevel count model was used. In very general terms, results showed that some individual and school features are associated with the likelihood of children attaining the daily amount of recommended MVPA, but not all with the same effect size and direction.

At the student-level, all variables but SES were related to children compliance. There was a positive association between sex and MVPA, in which boys achieve the guidelines more often than girls - a two-fold increase. Sex differences in PA levels and patterns are well-known [37], as boys are consistently more active than girls. Among Portuguese children, previous reports showed a clear sexual dimorphism in this behaviour [38-41]. It is often suggested that this disparity is related to cultural perceptions that favours boys´ engagement in more intense activities in contrast with girls that tend to prefer not so intense activities [42].

Children who sleep 10 or more hours per day achieve more frequently the 60 minutes recommendations than those who sleep less. Available data support this result, suggesting that children who spent more time in sedentary activities spend less time in bed and tend to sleep less [43-45]. In addition, children who sleep more tend to report higher PA levels [46, 47], and this may be due to the fact that engaging in higher intensity activity could enable children to fall asleep quicker and preserve healthy habits regarding their sleep patterns [46].

Evidence about PA and biological maturation kinks are inconsistent [48]. For example, Guinhouya et al. [49] examined the influence of biological maturation on PA recommendations in children (average age=9.9 yrs), and found no significant differences between advanced and delayed maturing children, but showed that those “on time” were the most physically active. Additionally, Fawkner et al. [50] reported that more mature girls may be more active than their less mature peers. In our sample no children was consider as an early maturer (data not shown), but those who were ahead on his/her biological maturation tended to comply more the daily MVPA recommendations.

Our results are somehow similar to those from Guinhouya et al. [49], whom suggested that advanced maturing children are more likely to achieve the recommendations. A possible explanation, as pointed out by Fawkner et al. [50], resides on the fact that in 5th grade the school environment tends to be more competitive than the primary school environment used to be, in which motor ability is valued more than effort, which may disfavor delayed or "on time" maturing children.

Being overweight/obese, spending more time in sedentary activities, and the use of an active transportation to school were negatively associated with the compliance of daily MVPA during a whole week. Available research showed mixed results between BMI and PA, although most often report that children and adolescents with higher BMI are less physically active [51, 52]. Portuguese children classified as overweight/obese comply less with the MVPA recommendations when compared with normal weighted ones. We suspect that with their bigger bodies these children tend to considerer themselves unhealthy and physically unfit and, as consequence, engage in less physical activities because they do not feel being able to change their status [53].

There is now more evidence that PA and sedentariness are two distinct behavioral traits [54], meaning that those children engaged in frequent sedentary activities do not necessarily imply that they spend lesser time in moderate-to-vigorous activities [55, 56]. However, in the Portuguese sample the more sedentary children were the less likely they attain the suggested MVPA daily recommendations and a possible explanation for this fact is that more time a child spends in sedentary activity, less time remains for use in moderate to vigorous activity.

It has been suggested that children active commuting to/from school is associated with higher PA levels [57]; further, those who do not do it are less likely to achieve the recommended MVPA daily levels [58]. Our results, however, run in a different direction because children who use an active transportation to school (such as walking, riding a bike, skating) have less chances to comply with the guidelines. Given the nature of Portuguese cities/urban aggregates, characterized by the availability of safe walkways, it is expected that children use different active transportation ways to school [59]. Additionally, most of the children of our study live in a short distance from their school (school enrollment

is based on family living proximities), which promotes the use of active way transportation. However, walking/cycling/skating to school does not necessarily mean that the total amount of daily MVPA increases because: (i) the traveled distance tends to be shorter which implies less time in this activity; [60] it may well be that the use of active transportation to school is not done with sufficient intensity and duration to increase the total amount of daily MVPA. It is also possible that those children less likely to achieve higher MVPA do not spend too much time in other physical activities. Another possible explanation is that children who use active transportation to school may spend their leisure time in sedentary activities, after school; while those children who drive to/from school can be involved in after school physical activities (such as sports clubs).

Schools' number of facilities and the number of intramural/interschool PA/sports programs, when dummy coded, have a significant and negative role in children achievement MVPA daily guidelines. It has been suggested that equipment availability and playground permanent structures are positively associated with higher PA levels [18], because they provide more opportunities for children to play, which probably increases their PA during break times [61]. However, among Portuguese children, the increasing availability of equipment related to sports facilities does not increase their PA levels, suggesting that during the break time children may chose more sedentary activities, such as sitting, talking, using portable games instead of more active activities.

Athletic facilities, such as sports offers, have been shown to be good opportunities to increase youth PA at school [62]. Again, in the present study children from schools with a higher percentage of sports offer had less chances to comply with the daily MVPA guideline. This can be explained firstly by the fact that schools sports offer is distinct from a mandatory school sports involvement. Moreover, our study only sampled 5th graders, the youngest at the school, and this can be an inhibitory factor to their involvement in school sports. Additionally, they usually are the smallest, thinner and, possibly, the least skilled in sports abilities than their older peers. Another possible explanation for this result may be that even if children are engaged in school sports this does not mean that they are physically active during the rest of day (when they are not training). Further, as we did not measure the frequency and duration of the

training section, it is not possible to estimate the amount of PA related to each training section.

The present study is not without limitations. Firstly, the sample comes from Portugal north region, which does not allow any generalization to all Portuguese children. However, the present sample has characteristics that do not differ from available data from previous Portuguese studies of the same age and sex namely in the prevalence of overweight/obesity, the percentage of children attaining MVPA daily guidelines, and SES distribution [9, 63, 64]. Secondly, we did not collect direct measures about the amount of time and intensity children spend in school sports' participation, as well as a precise measure of active school transportation. If available, this would surely provide a more reliable understanding of their influence on daily MVPA. Thirdly, we do not use information from the school context, such as the existence of programs to enhance healthy habits, the access availability to gymnasium and sports equipment outside school hours, and programs to promote PA, that could give more information regarding the school role in children achievement of MVPA guidelines. Despite these limitations, the study has several strong points: (1) the use of an objective instrument to estimate MVPA; (2) the use of the accelerometer for 7 consecutive days, comprising a typical week of children daily life routine; (3) sleep time was reliably estimated from a recent methodology; (4) the use of a relatively large sample from a very important developmental age; (4) the use of standard measurement methods and highly reliable data; (5) the use of an adequate statistical methodology to address the complexities of children and school combined data.

In summary, this study investigated the role of individual- and school-level variables in children's compliance with the recommended daily MVPA guidelines. Children individual level predictors are closely linked to their daily compliance. On the other hand, only two variables from the school context were deemed important, but with a negative direction. These results highlight that individual level characteristics have a more relevant role than the school context in regulating children compliance with the MVPA daily guidelines. These results should be taking into account when developing programmes and strategies to improve healthy behaviours in children.

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Capítulo 4

Síntese Final e Conclusões Gerais

Síntese final e conclusões gerais

É inquestionável a presença de uma elevada massa informativa oriunda da investigação da Epidemiologia da Atividade Física que procura descrever e interpretar a associação entre AF e saúde nas mais distintas populações e contextos socio-geográficos (Lobelo et al., 2014; Nyberg et al., 2011; Vander Ploeg et al., 2014). Um traço emergente dos resultados é o que refere a inatividade física como fator de risco para várias doenças crónicas na vida adulta (Chaput et al., 2013). Decorre daqui a necessidade de um melhor entendimento acerca do modo como as mudanças nas rotinas diárias podem influenciar positivamente a qualidade de vida a nível individual e a saúde pública em geral.

Níveis substanciais de AFMV têm sido associados a estilos de vida saudável, sobretudo com a redução do risco para desenvolvimento de doenças cardiovasculares (Metzger et al., 2010). Paradoxalmente, diferentes estudos em distintas regiões do planeta têm reportado que, globalmente, crianças e jovens tendem a não cumprir as recomendações diárias de 60 minutos de AFMV estabelecidas pela OMS (Armstrong & Welsman, 2006; Laguna et al., 2013; Telford et al., 2013). É óbvio que a pergunta que se coloca é exatamente esta – por quê? Não obstante a enorme quantidade de pesquisa, o fato é que ainda não temos uma explicação suficientemente satisfatória e unanimemente aceite acerca da complexidade dos mecanismos que podem estar por detrás desta epidemia global.

Num outro sentido, há evidência consistente que salienta a presença de uma multiplicidade de fatores a influenciar de modo distinto a variabilidade nos níveis e padrões de AFMV (Sallis et al., 2000). O seu entendimento mais esclarecido, associado a mecanismos biológicos, psicológicos, sociais e ambientais, será de grande importância no desenvolvimento futuro de programas de intervenção mais eficazes no aumento dos níveis de AF durante a infância e adolescência.

A presente dissertação procurou dar mais um contributo no esclarecimento destes problemas. Assim, foi nosso propósito verificar a frequência com que as crianças portuguesas, com 10 anos de idade, cumprem as recomendações diárias de AFMV, e identificar a importância de correlatos

biológicos, demográficos, sociais, psicológicos, ambientais e comportamentais na AFMV de crianças portuguesas. Além disso, preocupamo-nos em investigar o contexto onde a criança está inserida grande parte do seu dia - a escola.

Tabela 4: Síntese Final dos Resultados

Capítulo 2	**A count model to study correlates of 60 minutes of daily physical activity in Portuguese children** 1. Apenas 8.3% da amostra cumpre, nos sete dias da semana, as recomendações dos 60 minutos diários de AFMV; 2. Há uma tendência linear negativa para o cumprimento das recomendações diárias ao longo dos 7 dias, e a prevalência de crianças que cumpre as recomendações vai diminuindo à medida que aumentamos o número de dias; 3. Ser menina, apresentar um IMC mais elevado, pertencer a famílias de rendimento mais elevado e o incremento na distância entre a residência e um local desportivo reduz a probabilidade das crianças atenderem às recomendações diárias; 4. O maior tempo gasto em atividades fora de casa, depois da escola, aumenta a probabilidade de cumprir as recomendações diárias em 6.5%.
Capítulo 3	**Counting the number of days children meet moderate-to-vigorous physical activity. A multilevel modeling analysis** 1. Em média, os meninos cumprem 2.1 vezes mais as recomendações diárias de AFMV, comparativamente às meninas (em média, os rapazes cumprem aproximadamente 5 dias por semana); 2. As crianças obesas e com transporte ativo cumprem menos as recomendações diárias de AFMV, sendo que as obesas apresentam 16% menos chances de cumprir as recomendações;

3. As crianças mais maturas e que têm maior tempo de sono têm mais chances de cumprir as recomendações diárias de AFMV;
4. De todos os preditores analisados, a nível da escola, apenas dois mostraram ser significativos: o número de facilidades desportivas e número de desportos oferecidos na escola, porém mostraram um efeito negativo no cumprimento das recomendações.

Implicações dos resultados e perspetivas futuras

Ainda que localizado no intervalo etário dos 9-11 anos, os resultados da presente pesquisa podem ser de importância para os professores de Educação Física, pais e agentes responsáveis pela implementação de programas de intervenção ao nível local e nacional. Apesar de não haver um Observatório Nacional que tenha um propósito de vigilância epidemiológica dos níveis de sedentarismo à escala do país, é nosso entendimento que os resultados disponibilizados nesta pesquisa podem ser de grande utilidade para os organismos que lutam contra a doença complexa que é a obesidade infantil e juvenil, sobretudo ao nível da prevenção primária.

Do mesmo modo, pensamos que, ao contrário do que parece ocorrer, é importante que o desenho e a implementação de programas ao nível das autarquias, juntas de freguesia e clubes desportivos, seja balizado por um pensamento e ação fundados em evidências consistentes da literatura internacional respeitada e de impacto. Neste sentido, os resultados desta pesquisa podem ser um auxiliar precioso.

Dado que uma das obrigações do ISCOLE em Portugal era fornecer, a cada escola e família, um relatório detalhado dos resultados, é nossa expectativa que possam servir de referência na implementação mais esclarecida de programas de prevenção primária e secundária.

Não obstante a latitude e a profundidade do projeto ISCOLE em Portugal, há que referir que no futuro o seu maior desafio repousa na

possibilidade de seguir longitudinalmente estas crianças e perceber melhor as alterações que decorrem do complexo processo de crescimento e desenvolvimento na diversidade dos seus contextos de vida.

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