



# Exploring the Associations Between Physical Activity Intensity and Adolescent Mental Health: A Dual Factor Model Perspective

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**KEYWORDS:** HBSC, ADOLESCENTS, PHYSICAL ACTIVITY, MENTAL HEALTH, DUAL FACTOR MODEL

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## Resumo

A atividade física tem demonstrado ter inúmeros benefícios para a saúde. Contudo, sabe-se menos sobre a relação entre a atividade física e a saúde mental. Este estudo examina a relação entre a intensidade da atividade física e a saúde mental em adolescentes, centrando-se na atividade física moderada a vigorosa (AFMV) e na atividade física vigorosa (AFV) sobre a satisfação com a vida e os sintomas psicossomáticos. Utilizando dados do inquérito Health Behaviour in School-aged Children (HBSC), foram incluídos nas análises 17175 adolescentes flamengos com idades compreendidas entre os 10 e os 19 anos. Os dados foram analisados utilizando modelos de regressão linear múltipla contendo variáveis de idade e género para examinar as associações entre estas intensidades de atividade física e as dimensões positivas e negativas do bem-estar mental, com base no modelo de duplo fator de saúde mental. Os resultados mostraram que tanto a AFMV como a AFV estavam positivamente associadas à satisfação com a vida e inversamente associadas à prevalência de sintomas psicossomáticos. Cada dia adicional de 60 minutos de AFMV foi associado a um aumento de 0,103 unidades na satisfação com a vida ( $p < 0,001$ ), enquanto cada unidade adicional de AFV foi associada a um aumento de 0,119 unidades na satisfação com a vida ( $p < 0,001$ ). Estes modelos explicaram 6,2% e 6,4% da variância da satisfação com a vida, respetivamente. Para cada dia adicional de AFMV, houve uma diminuição de 0,033 unidades nos sintomas psicossomáticos ( $p < 0,001$ ), enquanto para cada unidade adicional de AFV, houve uma diminuição de 0,043 unidades ( $p < 0,001$ ). Estes modelos explicaram 12,6% e 12,8% da variância dos sintomas psicossomáticos, respetivamente. Embora exista uma associação estatisticamente significativa, o efeito das associações foi relativamente pequeno, sugerindo que, embora a atividade física tenha um efeito positivo na saúde mental dos adolescentes, é provável que seja apenas um dos muitos fatores que contribuem para tal. Os resultados do presente estudo reforçam a associação positiva entre a atividade física e a saúde mental dos adolescentes e salientam que a AFV pode estar associada a níveis mais elevados de satisfação com a vida e a uma redução dos sintomas psicossomáticos, em particular os sintomas psicológicos. Este estudo tem como objetivo realçar a importância da atividade física na saúde mental das crianças e dos jovens.

## Abstract

Physical activity has been shown to have many health benefits. Less is known about the relationship between physical activity and mental health. This study examines the relationship between physical activity intensity and mental health outcomes in adolescents, focusing on moderate-to-vigorous physical activity (MVPA) and vigorous physical activity (VPA) on life satisfaction and health complaints. Using data from the Health Behaviour in School-aged Children (HBSC) survey, 17175 Flemish adolescents aged 10-19 years were included in the analyses. Data were analysed using multiple linear regression models, including covariates age and gender, to examine the associations between these physical activity intensities and both positive and negative dimensions of mental well-being, based on the dual-factor model of mental health. Results showed that both MVPA and VPA were positively associated with life satisfaction and inversely associated with the prevalence of health complaints. Each additional day of 60 minutes MVPA was associated with a 0.103 unit increase in life satisfaction ( $p < 0.001$ ), while each additional unit of VPA was associated with a 0.119 unit increase in life satisfaction ( $p < 0.001$ ). The models explained 6.2% and 6.4% of the variance in life satisfaction, respectively. For each additional day of MVPA, there was a 0.033 unit decrease in health complaints ( $p < 0.001$ ), while for each additional unit of VPA, there was 0.043 units decrease ( $p < 0.001$ ). These models explained 12.6% and 12.8% of the variance in health complaints, respectively. Although there is a statistically significant association, the effect of the associations was relatively small, suggesting that while physical activity has a positive effect on adolescents' mental health, it is likely to be only one of many contributing factors. The results of this study reinforce the positive association between physical activity and mental health in adolescents and highlight that VPA may be associated with higher levels of life satisfaction and a reduction in health complaints, particularly psychological complaints. This study aims to emphasize the importance of physical activity in the mental health of children and young people.

## **List of abbreviations**

WHO – World Health Organization

HBSC – Health Behaviour in School-aged Children

PA – Physical Activity

LPA – Light Physical Activity

MPA – Moderate Physical Activity

MVPA – Moderate to Vigorous Physical Activity

VPA – Vigorous Physical Activity

LS – Life Satisfaction

HC – Health Complaints

## **A guide how to read this dissertation**

The work is divided into chapters for the purpose of facilitating a more coherent and accessible reading experience. The initial chapter is dedicated to defining the fundamental concepts that are relevant to the field of mental health. This includes providing clear definitions and an explanation of the dual factor model approach. Furthermore, it outlines the diverse dimensions, intensities, and forms of physical activity, as well as the sedentary behaviour concept. Subsequently, the second chapter presents a review of the literature on the current issues related to physical activity and mental health in adolescents. A review of the literature and an analysis of HBSC trends on these topics are presented. Subsequently, the objectives of this study are delineated, along with a description of the existing literature gap and the necessity for further investigation. The third chapter outlines the methodology employed in the investigation, including the data collection process, the characteristics of the sample, the variables and measures included in the study, and the analytical techniques used to analyse the data. The fourth chapter presents the results of the study, while the fifth chapter discusses the implications of the findings, the limitations of the study, and potential future directions. The sixth chapter presents a summary of the key findings and conclusions.

## Introduction

The objective of the behavioural and social sciences is to gain a more profound comprehension of human behaviour and to utilise this understanding to enhance people quality of life. Given the significant influence of physical activity behaviour on health, it can be seen as an indispensable element in the study of individual and collective health. This leads us to a question. Nowadays, with the increase in mental health problems among young people, it is essential to update the current situation by investigating and exploring it. What implications might an association between physical activity and mental health have for the promotion of physical activity?

Engaging in regular physical activity has been shown to have multiple benefits across the entire lifespan ( *ACSM's Guidelines for Exercise Testing and Prescription.*, 2021 ; Lavin et al., 2022) being an effective behaviour for disease prevention and health promotion (Poitras et al., 2016). The results of studies conducted with adolescents demonstrate that physical activity can positively impact general physical and psychological health (Janssen & LeBlanc, 2010; Lavin et al., 2022), well-being and social interaction (Eime et al., 2013; McMahon et al., 2017), contributing to improve quality of life, while reducing the risk of chronic disease and mortality (Bleich et al., 2018; Dhuli et al., 2022; Granero-Jiménez et al., 2022; Rodriguez-Ayllon et al., 2019).

Besides physical and social improvements, that logically are all interrelated, there is a growing body of evidence documenting the beneficial effects of physical activity on mental health of children and adolescents (Biddle & Asare, 2011; Biddle et al., 2019; Rodriguez-Ayllon et al., 2019). Research has shown that physical activity can lead to reduced symptoms of depression, anxiety (Biddle et al., 2019), and general health complaints (Baceviciene et al., 2019; Marques et al., 2019) while enhancing overall mood and well-being through improving life satisfaction and happiness (Chmelík et al., 2021; Feng et al., 2022; Kleszczewska et al., 2018; Villafaina et al., 2021; Zhang & Chen, 2019).

Given the persistently low levels of physical activity and the current rise in mental health concerns, investigating the relationship between these variables holds significant promise for informing future practice (Guthold et al., 2020). This study aims to understand this relationship by employing two established measures of mental health in adolescents and two different intensity levels of physical activity. To achieve this, variables from the Flemish HBSC survey was used, such as MVPA, VPA, life satisfaction and health complaints.

## **Definitions and concepts**

### **Mental Health**

The lack of consensus on the definitions of mental health and well-being within the literature is evident, despite the multitude of studies conducted on these concepts (Avedissian & Alayan, 2021; Biddle et al., 2019). The World Health Organization (WHO) typically offers the most overarching definitions, emphasizing mental health as “a state of mental well-being that enables people to cope with the stresses of life, realize their abilities, learn well, and work well, and contribute to their community. Mental health is an integral component of health and well-being and is more than the absence of mental disorder” (World Health, 2022b). Well-being, is considered a broader concept as a positive state of health experienced by individuals, determined by social, economic and environmental conditions that includes positive states of physical, social and mental health (WHO, 2021). These positive aspects are often referred by perceived happiness and life satisfaction (WHO, 2021). Mental illness or psychopathology, on the other hand, refers to a wide range of negative conditions that affects a person’s mood, thinking, and behaviour. These conditions, such as depression, anxiety or other disorders diagnosed by medical guidelines, can significantly impair a person’s ability to function in various aspects of life (World Health, 2022b).

Two of the most observed variables in the context of mental health literature are life satisfaction (LS) and health complaints (HC). LS is a comprehensive assessment of an individual's overall life experience and a central concept in positive psychology (Gilman & Huebner, 2003) . It emphasises the evaluative aspects of mental well-being, focusing on the overall content of life rather than just health-related satisfaction. In contrast to immediate emotional responses such as happiness, or traditional mental health assessments, which focus primarily on the presence or frequency of problems and symptoms, LS reflects stable cognitive evaluations over time, offering valuable insights into individuals' perceptions of their life situations and well-being (Pavot & Diener, 1993), while being closely related to mental health risks (Guzmán et al., 2020). Health complaints are self-reported individual and subjective non-clinical health symptoms, that frequently occur together providing an important indicator of mental health and well-being in adolescents (Brill et al., 2001). Using the multiple health complaints scale enables the assessment of both psychological and somatic complaints, which may indicate the first signs of more severe mental health issues (Kinnunen et al., 2010). Furthermore, in adolescents, these complaints are typically correlated with stress and anxiety (Brill et al., 2001).

## **Dual Factor Model**

Mental health and mental illness are two distinct yet interconnected concepts. Mental health, as stated by World Health Organization (2022), extends beyond the mere absence of mental illness and these two concepts should not be perceived as two opposite ends of one continuum (Eriksson et al., 2019). This conception of mental health integrates both illness and well-being, which could also be applicable to the conception of health in general (WHO, 1948). The holistic approach emphasises the importance of a focus on positive mental health rather than just on individual problems.

Within this framework, the dual-factor model of mental health introduced by Greenspoon and Saklofske (2001), emerges as a crucial conceptual tool. This model emphasises the importance of considering that mental health exists along a continuum spectrum, with both positive attributes, such as life satisfaction, and negative outcomes, such as health complaints. Greenspoon and Saklofske (2001) systems model aimed to integrate subjective well-being and psychopathology when analysing mental health, noting that an increase in one does not necessarily mean a decrease in the other. This framework suggests that both positive and negative indicators should be taken into account when addressing youth's mental health (Suldo & Shaffer, 2008), thereby offering a more holistic understanding of mental health, focusing on positive aspects rather than just on individual problems (Antaramian et al., 2010; Westerhof & Keyes, 2010).

## **Physical Activity**

Physical activity can be defined as any physical movement that increases energy expenditure above resting levels (Caspersen et al., 1985) and is characterized as a complex behaviour, manifesting in a variety of forms and contexts including free play, domestic tasks, exercise, physical education classes and organized sport (Malina et al., 2004). Sedentary behaviour, characterised by low energy expenditure (energy expenditure  $\leq 1.5$  metabolic equivalents (METs)), while sitting, lying down or reclining, often linked with screen time. This are two distinct but interrelated lifestyle habits. (Tremblay et al., 2017) Exercise, a term often used synonymously with physical activity, refers to a specific subset of physical activity. Unlike general physical activity, exercise is characterized by being planned, structured and repetitive where the primary or intermediate goal is to improve or maintain physical fitness (Caspersen et al., 1985).

It is important to note that MVPA (Moderate-to-Vigorous Physical Activity) and VPA (Vigorous Physical Activity) represent two different dimensions of physical activity. MVPA

provides an overall assessment of physical activity, which aligns with current policy guidelines for health-enhancing physical activity (Ainsworth et al., 2011). MVPA is defined by the WHO as physical activity performed at an intensity greater than 3 MET on absolute scale (MET = metabolic equivalent, standardized for resting metabolic rate (RMR) as 1 MET = 3.5 mL/kg/min) (Herrmann et al., 2024). On a scale relative to an individual's personal capacity, MVPA is usually rated 5 or higher on a scale of 0-10 (Bull et al., 2020). MVPA normally involves activities that increase breathing rate and may include carrying light loads, cycling at a regular pace, or playing doubles tennis.

In contrast, VPA is defined as activity performed at 6 or more METs; and on individual's personal capacity, it is typically rated as a 7 or 8 on a scale of 0-10 (Bull et al., 2020). VPA is common to be specifically associated to recreational activities, sports, or hobbies that significantly increase breathing rate and cause sweating (Ainsworth et al., 2011).

Research among adolescent girls has demonstrated that the latent variables representing VPA and MVPA are independent of each other (Biddle & Asare, 2011; Motl et al., 2004). This suggests that these two measures reflect different levels of engagement in physical activity behavioural patterns and may lead to different health outcomes.

## **Literature review Physical Activity and Mental Health in adolescence**

### **Mental Health**

Adolescence is a critical period of life that occurs between childhood and adulthood, typically between the ages of 10 and 19, as defined by the WHO and is commonly viewed as a healthy and energetic stage of life (National Academies of Sciences et al., 2019; WHO, 2023). However, the emergence of numerous non-communicable diseases (NCDs) later in life can be attributed, at least in part, to modifiable risk behaviours established during this formative period. (National Academies of Sciences et al., 2019; Patton et al., 2016). This period is characterised by significant biological, emotional, psychosocial, and cognitive changes that lead to inherent adaptability and growth (National Academies of Sciences et al., 2019; WHO, 2023). The interplay between biology and environment shapes adolescent development. While the adolescent brain is adaptable to learning and growth, it can also be vulnerable to risk behaviours, including smoking, unhealthy eating habits, and lack of physical activity (Avedissian & Alayan, 2021; National Academies of Sciences et al., 2019; van Sluijs et al., 2021).

Understanding adolescent mental health is crucial, as many of mental disorders emerge and are prevalent during this critical developmental period. In recent decades adolescents have experienced significant changes due to technological advancements, global conflicts and more recently the COVID-19 pandemic has further exacerbated these challenges for adolescents, especially impacting their mental health (Residori et al., 2023).

Globally, one in seven, (14%) 10-19-year-olds experience a mental disorder, accounting for 13% of the global burden of disease in this age group (World Health, 2022b). Current cohorts (Boer et al., 2023; Cosma et al., 2023) report higher prevalence of poorer mental health than previous generations, particularly among girls and older adolescents during the last two decades (Bor et al., 2014). Depression, anxiety, and behavioural disorders are among the leading causes of illness and disability among adolescents (WHO, 2023). However, international comparative studies have shown that time trends in adolescent mental health vary significantly across countries (Cosma et al., 2020). In the case of Europe and Belgium, the prevalence of mental disorders among individuals between the ages of 10 and 19 is particularly elevated, with 16% of individuals in Europe and 18% of individuals in Flanders within this age group experiencing mental disorders (IHME, 2019).

## **HBSC work**

A review of the HBSC study data reveals a notable increase in the prevalence of self-reported multiple health complaints among adolescents over recent years. In 2022, 44% of adolescents reported experiencing two or more symptoms once a week. This trend has been consistent, with prevalence rates rising from 33% in 2014 to 36% in 2018, and further to 44% in 2022 (Cosma et al., 2023). In Flanders 40 % of adolescents report multiple health complaints more than once a week (HBSC, 2023) Conversely, when examining a positive indicator of mental health, life satisfaction, as measured by the 2021/2022 HBSC survey, was 7.5 out of 10 across all regions and countries. In Flanders the scenario was similar scoring 8 for all adolescents (HBSC, 2023).

## **Physical Activity**

It is recommended by the WHO that children and adolescents between 5 and 17 should do at least an average of 60 minutes per day of moderate to vigorous-intensity physical activity (MVPA) and also should incorporate vigorous-intensity physical activity (VPA) aerobic activities, as well as those that strengthen muscle and bone, at least 3 days a week (Bull et al., 2020; WHO, 2018). Despite the considerable evidence highlighting the health benefits of physical activity, a recent pooled analyse with 1.6 million participants (Guthold et al., 2020), conclude that 81% of adolescents often fail to meet recommended physical activity guidelines, with adolescent girls reporting worse outcomes than adolescent boys, (85% girls vs.78% boys) (Dumith et al., 2011; Guthold et al., 2020; World Health, 2022a). The decline in physical activity may be caused by various factors, such as sedentary behaviours during leisure time and at home, as well as an increasing dependence on passive modes of transportation (Rodriguez-Ayllon et al., 2019). There is also evidence showing that young people from lower socioeconomic tend to be less physical active, however this difference seems to be not well established regarding mostly from the type and intensity of physical activity (Stalsberg & Pedersen, 2010, 2018).

## **HBSC work**

In Europe the prevalence of MVPA has remained persistently low over the past two decades, with minimal change noted (Rakić et al., 2024). Conversely, levels of VPA have demonstrate relative stability although at higher rates, within the time frame of 2002 and 2014 (Inchley et al., 2017; Kalman et al., 2015). This pattern is mirrored in Flanders, where also 80% of adolescents do not meet the recommend PA levels. Notably, disparities emerge across gender and age groups, with girls (14.0%) and older adolescents (18.5%;15-17 years) exhibiting lower

engagement in physical activity, contrasting with boys (25%) and younger age groups (Dierckens, 2023). It has been demonstrated that age, gender, and socioeconomic differences may act as mediators and influencers of physical activity levels, particularly in girls across all age groups and older adolescents (aged 15-17) who report lower levels of overall physical activity (Inchley et al., 2017). Furthermore, the participation in vigorous physical activity (VPA) is shown to be graded based on family affluence. Girls and boys from higher affluence families engage in more VPA than those from lower affluence families.

### **Physical activity and Mental Health during adolescence**

The literature suggests that physical activity can be used both in prevention and treatment of common mental disorders making it a powerful determinant of mental health in adolescents (Lubans et al., 2016; Rodriguez-Ayllon et al., 2019; Saxena et al., 2005). Physical inactivity is a significant risk factor for morbidity and mortality from various chronic diseases, such as cardiovascular disease, cancer, metabolic disease, and neurodegenerative disease. Adolescents who engage in insufficient physical activity and spend more time in sedentary behaviours are more likely to experience somatic and psychological complaints (Baceviciene et al., 2019; Khan et al., 2021; Rodriguez-Ayllon et al., 2019). In other hand, engaging in regular physical activity is proven to help not only in the reduction of symptoms and complaints but also in to enhance several mental health outcomes such as, life satisfaction, happiness, quality of life and cognitive performance (Biddle et al., 2019; Villafaina et al., 2021).

### **HBSC work**

Previous studies using data from the Health Behaviour in School-aged Children (HBSC) survey, have examined the relationship between physical activity and life satisfaction (Brooks et al., 2014; Chmelík et al., 2021; Feng et al., 2022; Lábiscsák-Erdélyi et al., 2022; Meyer et al., 2021; Molcho et al., 2021; Slapšinskaitė et al., 2020). Similar analyses have been conducted regarding the relationship between PA and health complaints (Baceviciene et al., 2019; Husárová et al., 2015; Marques et al., 2019). The results of these studies indicate that people who engage in more physical activity tend to report higher life satisfaction and fewer health-related psychosomatic complaints, which contributes to the hypothesis of this study. However, there has been less research on the differentiation of physical activity intensities and their specific effects (Khan et al., 2021; Molcho et al., 2021).

### **Study objectives**

Most previous studies often focus on one positive, or negative indicator of adolescent mental health leaving a gap in our understanding of mental health. It is important to note that an increase in one indicator does not necessarily correspond to a decrease in the other. Incorporating the dual-factor model of mental health contributes to a more holistic understanding of this issue. The relationship between life satisfaction and health complaints, along with different levels of physical activity, has received less research attention. The aim of this study is to examine the relationship between adolescent MVPA and VPA levels, along with life satisfaction and health complaints outcomes. This study hypothesizes that high participations of MVPA and VPA would be associated with higher life satisfaction and fewer health complaints in adolescents.

## **Methods**

### **Study design and sample**

To address the research questions, data from the cross-sectional Health Behaviour in School-aged Children (HBSC) study is used. This study, conducted every four years in collaboration with the WHO Regional Office for Europe, is a large school-based self-reported survey assessing adolescent health and health behaviours. The data provides valuable information at national, regional, and international levels, offering insights of representative samples of 11-, 13- and 15- year-old adolescents, across 50 countries and regions in Europe, Central Asia, and Canada (Inchley J, 2021/22).

For this study only data from Flanders was used. The survey for the 2021/2022 edition was conducted between February 2022 to June 2022. In Flanders, however, the age range is extended and students from the 5<sup>th</sup> till 12<sup>th</sup> grade, both in primary and secondary schools are included from the Flanders list of schools. Adolescents were selected using a combination of cluster sampling and random sampling techniques: first, schools were chosen as clusters, and then within each selected school, classes were randomly selected, ensuring a representative sample of a minimum of 1,500 students per age group. This approach accounts for the fact that clustering does not allow the students' responses to be viewed as completely independent of each other. Participation in the study was entirely voluntary and anonymous. The study was approved by the Ethics Committee of the University Hospital of Ghent.

The dataset contains data from 197 schools, 1659 classes, totalizing with a final sample of 20 154 students after a final response rate of 69.5% at the student level. The total sample consists of 10 177 boys (50.5%) and 9 664 (48.0%), 313 students (1.6%) did not complete the gender question.

### **Measures**

#### **Life Satisfaction**

Life satisfaction is considered as a positive aspect of mental health and a dependent variable of this study. Adolescents were asked to rate their general life satisfaction using the Cantril Ladder visual analogue scale (Cantril, 1965). The Cantril Ladder comprises 11 steps with values ranging (from 0-10). The top (10) indicates “the best possible life”, while the bottom (0) represents “the worst possible life” (Inchley J, 2021/22). Minor amendments were made to the original item to ensure its suitable for use by 11-year-olds (Levin & Currie, 2014). This measure is coded as a continuous variable, leading to a continuous score between 0 and 10. In the

interpretation of the results, it is considered that higher scores comprehend a higher Life Satisfaction.

The Cantril Ladder is a well-established instrument in research, used as a measure of life satisfaction for decades. Levin and Currie (2014) reported good validity and reliability with other emotional well-being measures, perceived health and subjective health (Inchley J, 2021/22).

### **Multiple health complaints**

Multiple health complaints are considered as a negative aspect of mental health and the second dependent variable of this study. The Multiple Health Complaints scale includes eight complaints: four physical (headache, abdominal pain, backache, feeling dizzy) and four psychological (feeling low, irritability or bad mood, feeling nervous, and difficulties sleeping). Participants are asked to report “In the last 6 months: how often have you had the following...?” Item 1 – Headache; item 2 – Stomachache; item 3 – backache; item 4 – feeling low; item 5 Irritability or bad temper; item 6 – feeling nervous; item 7 - feeling nervous; item 8 – feeling dizzy. The possible answers for all the 8 items are on a five-point scale ranging from 1- about every day; to 5- rarely or never. The multiple health complaints scale has acceptable test-retest reliability and validity for the scale as a whole (Inchley J, 2021/22). This measure is coded as a continuous variable where a new variable of the mean scores for the overall scale was created. This means that the higher the score, less complaints were reported. A separate variable for a mean of somatic and psychological complaints was created.

### **Moderate to vigorous physical activity (MVPA)**

Moderate-to-Vigorous Physical Activity provides a comprehensive assessment of overall physical activity, with a particular focus on adherence to current policy recommendations. This measure aligns with past international recommendations stipulating a minimum of 60 minutes of moderate-to-vigorous activity daily. Recent revisions to guidelines have shifted towards an average of 60 minutes per day, however efforts are underway to devise new measurement tools to facilitate monitoring in accordance with the updated guidelines. Until these measures are developed and validated, the existing MVPA items will persist in use (Inchley J, 2021/22; Prochaska et al., 2001).

MVPA is considered one independent variable in this study and was measured using the following item: “Physical activity is any activity that increases your heart rate and makes you

get out of breath some of the time” (Rakić et al., 2024) (Rakić et al., 2024). Physical activity can be done in sports, school activities, playing with friends, or walking to school. Some examples of physical activity are running, brisk walking, rollerblading, biking, dancing, skateboarding, swimming, soccer, basketball, football, and surfing. On how many of the past seven days have you been physically active for a total of at least 60 minutes per day if you add up all the separate exercise moments of that day ” Response options ranged between “zero days” and “seven days” per week (Inchley J, 2021/22).

The Moderate-to-Vigorous Physical Activity (MVPA) item utilised in the HBSC survey was originally proposed and validated in a study by (Prochaska et al., 2001). This item has since been validated and adopted in numerous studies and surveys globally, underscoring the item's utility in assessing adolescent physical activity levels. The findings reveal consistently strong test-retest reliability across various time intervals and populations, with Intraclass Correlation Coefficients (ICCs) ranging from 0.74 to 0.84, indicative of substantial to excellent reliability. Moreover, moderate to substantial agreement with criterion measures, such as accelerometer data and adherence to physical activity guidelines, further supports the validity of the MVPA item (Inchley J, 2021/22). This measure is coded in a numeric equivalent of the number of days that MVPA was practiced.

### **Vigorous Physical Activity (VPA)**

Vigorous physical activity (VPA) was measured with the following two items. The first item asked about the frequency of vigorous activity: “Outside school hours: How often do you exercise in your free time so much that you get out of breath or sweat?” (Inchley J, 2021/22). Response options are coded as follows: Every day=7, 4-6 times a week=6, 3 times a week=5, 2 times a week=4, once a week=3, once a month=2, less than once a month=1, never=0.

The incorporation of Vigorous Physical Activity (VPA) items into the HBSC study can be traced back to 1985/86, with variations in their inclusion over subsequent survey cycles. Initially, both the frequency and duration of VPA were assessed, but due to concerns regarding the validity of the duration item, it was later removed from the mandatory questionnaire. Notably, Booth et al. (2001) conducted a comprehensive evaluation of the HBSC VPA items, revealing good reliability (67% to 85%) and significant associations between VPA engagement and fitness levels among Australian adolescents. Further validation efforts by Rangul et al. (2008) demonstrated the reliability of HBSC VPA items, with fair validity when compared to maximal oxygen consumption (VO<sub>2</sub>max).

## **Data analyses**

All statistical analyses were conducted using the SPSS 29.0 software. In this study, a subset of the data was utilised, comprising only participants who had complete data on gender, age, physical activity, and mental health questions. Following the deletion of all cases with missing values, the sample for this study consisted of 17,175 participants and all subsequent analyses were conducted on this sample. The definition of adolescence by the (WHO, 2023) comprehend adolescents between 10 and 19. However in this study all adolescents enrolled in the school with valid data were included, regardless of their age.

Descriptive analyses were conducted to summarize the sample characteristics (**Table 1**), including means and standard deviation for continuous variables, and frequencies for categorical variables. Independent samples t-tests were conducted to compare means of Life Satisfaction, Multiple Health Complaints, MVPA and VPA between boys, girls, younger adolescents, and older adolescents. A cut off point of 15 was used to separate older and younger adolescents. The majority reports from HBCS and WHO regarding children and adolescents tend to assume 15 as a turn point age. The same methodology was used in this study.

Multiple linear regression models were constructed to examine the relationships between physical activity levels and mental health outcomes (**Table 2, Table 3, Table 4, Table 5**). Levene's Test for equality of variances was used to assess the homogeneity of variances. Kolmogorov-Smirnov tests were used to assess the normality of the variables in study. For each regression model, the standardized residuals were saved, and diagnostic tests conducted, including tests for multicollinearity (Variance Inflation Factor), homoscedasticity (scatter plots of residuals), and independence of errors (Durbin-Watson statistic).

## Results

### Characteristics of population

The minimum age was 9.17 years, while the maximum was 22.50 years. The mean age of participants was 14.7 (2.32) years. There are 16 students below the age of 10 and 39 students above the age of 20. **Table 1** below presents the descriptive statistics, for the total sample, for boys and girls and for younger and older adolescents.

Table 1 - Indicators of physical activity and mental health by age group and gender

	<b>Boy M(SD)</b>	<b>Girl M(SD)</b>	<b>Younger adolescents M(SD)</b>	<b>Older Adolescents M(SD)</b>	<b>Total M (SD)</b>	<b>Range</b>
Life Satisfaction (0-10)	7.84 (1.51)	7.44 (1.63)	7.85 (1.58)	7.41 (1.55)	7.64 (1.58)	0-10
Health Complaints (0-5)	3.97 (0.77)	3.42 (0.94)	3.80 (0.88)	3.57 (0.91)	3.69 (0.90)	1-5
MVPA (0-7)	4.74 (1.97)	3.92 (2.02)	4.43 (1.97)	4.21 (2.10)	4.33 (2.03)	0-7
VPA (0-7)	5.05 (1.74)	4.26 (1.90)	4.86 (1.72)	4.42 (1.98)	4.65 (1.86)	0-7

Independent samples t-tests were conducted to compare the means of life satisfaction, health complaints, MVPA, and VPA between boys and girls. The results indicated that boys reported significantly higher life satisfaction ( $t(17040.645) = 16.748$ ,  $p < .001$ ,  $MD = 0.401$ ), fewer health complaints ( $t(16475.793) = 42.122$ ,  $p < .001$ ,  $MD = 0.55387$ ), more days with 60 minutes

of physical activity ( $t(17147.733) = 26.867, p < .001, MD = 0.817$ ), and more frequent vigorous physical activity ( $t(17010.170) = 28.399, p < .001, MD = 0.788$ ) compared to girls.

Independent samples t-tests were also conducted to compare life satisfaction, health complaints, MVPA, and VPA between younger and older adolescents. The results indicated that younger adolescents reported significantly higher life satisfaction ( $t(17173) = 18.505, p < 0.001, MD = 0.443$ ); less health complaints ( $t(16656.418) = 16.541, p < 0.001, MD = 0.22755$ ); higher levels of MVPA ( $t(16505.564) = 7.076, p < 0.001, MD = 0.221$ ); and higher levels of VPA ( $t(15919.562) = 15.441, p < 0.001, MD = 0.441$ ). These results underscore the significance of incorporating both sex and age as covariates in regression analyses.

### Meeting guidelines

There is a total of 20.8% of the population that adhere to the guidelines of at least 60 minutes per day for MVPA. Regarding VPA, 61.5% of adolescents practice 3 or more days a week.

### Regression analyses

#### Model 1 – Association between life satisfaction and MVPA

Life Satisfaction as dependent variable, with MVPA age and gender as predictors.

Table 2 - Model 1

Coefficients <sup>a</sup>						
Model	Unstandardized Coefficients			Sig.	95.0% Confidence Interval for B	
	B	Std. Error	t		Lower Bound	Upper Bound
1 (Constant)	9,327	0,092	100,853	0,000	9,146	9,509
MVPA	0,103	0,006	17,425	0,000	0,091	0,114
Age	-0,110	0,005	-21,849	0,000	-0,120	-0,100
Boy or Girl	-0,338	0,024	-14,138	0,000	-0,385	-0,291

a. Dependent Variable: Life satisfaction

A multiple linear regression was conducted to predict life satisfaction from MVPA, age, and gender. The overall regression was statistically significant,  $F(3, 17171) = 380.942, p < 0.001$ , and accounted for approximately 6.2% of the variance in life satisfaction ( $R^2 = 0.062$ , Adjusted  $R^2 = 0.062$ ). MVPA was a significant positive predictor of life satisfaction ( $B = 0.103, SE =$

0.006,  $t = 17.425$ ,  $p < 0.001$ ). This suggests that for each additional day of engaging in 60 minutes of physical activity, life satisfaction increases by 0.103 units, holding other variables in constant. The Durbin-Watson statistic was 1.820, indicating no significant autocorrelation in the residuals.

### Model 2 – Association between life satisfaction and VPA

Life satisfaction as the dependent variable, with VPA, age and gender as predictors.

Table 3 - model 2

Coefficients <sup>a</sup>						
Model	Unstandardized			Sig.	95.0% Confidence	
	Coefficients		t		Interval for B	
	B	Std. Error			Lower Bound	Upper Bound
2 (Constant)	9,096	0,097	93,335	0,000	8,905	9,287
VPA	0,119	0,007	18,287	0,000	0,106	0,132
Age	-0,103	0,005	-20,271	0,000	-0,113	-0,093
Boy or Girl	-0,327	0,024	-13,632	0,000	-0,374	-0,280

a. Dependent Variable: Life satisfaction

A multiple linear regression was conducted to predict life satisfaction from vigorous physical activity (VPA), age and gender. The overall regression was statistically significant,  $F(3, 17171) = 391.701$ ,  $p < 0.001$ , and accounted for approximately 6.4% of the variance in life satisfaction ( $R^2 = 0.064$ , Adjusted  $R^2 = 0.064$ ). VPA was a significant positive predictor of life satisfaction ( $B = 0.119$ ,  $SE = 0.007$ ,  $t = 18.287$ ,  $p < 0.001$ ). This suggests that for each additional unit of vigorous physical activity, life satisfaction increases by 0.119 units. The Durbin-Watson statistic was 1.814, indicating no significant autocorrelation in the residuals.

### Model 3 – Association between health complaints and MVPA

Health complaints as the dependent variable, with MVPA age and gender as predictors.

Table 4 - model 3

Coefficients <sup>a</sup>

Model	Unstandardized Coefficients		95.0% Confidence Interval for B			
	B	Std. Error	t	Sig.	Lower Bound	Upper Bound
3 (Constant)	5,249	0,051	102,810	0,000	5,149	5,349
MVPA	0,033	0,003	10,304	0,000	0,027	0,040
Age	-0,061	0,003	-21,819	0,000	-0,066	-0,055
Boy or Girl	-0,538	0,013	-40,767	0,000	-0,564	-0,512

a. Dependent Variable: Health Complaints

A multiple linear regression was conducted to predict health complaints from moderate-to-vigorous physical activity (MVPA), age and gender. The overall regression was statistically significant,  $F(3, 17171) = 821.772$ ,  $p < 0.001$ , and accounted for approximately 12.6% of the variance in health complaints ( $R^2 = 0.126$ , Adjusted  $R^2 = 0.126$ ). **MVPA** was a significant positive predictor of health complaints ( $B = 0.033$ ,  $SE = 0.003$ ,  $t = 10.304$ ,  $p < 0.001$ ). This suggests that for each additional day of moderate-to-vigorous physical activity, the frequency of health complaints decreases by 0.033 units. The Durbin-Watson statistic was 1.564, indicating no significant autocorrelation in the residuals.

#### Model 4 - Association between health complaints and VPA

Health complaints as the dependent variable, with VPA age and gender as predictors.

Table 5 - model 4

Coefficients<sup>a</sup>

Model	Unstandardized Coefficients			Sig.	95.0% Confidence Interval for B	
	B	Std. Error	t		Lower Bound	Upper Bound
	4 (Constant)	5,140	0,054		95,564	0,000
VPA	0,043	0,004	12,034	0,000	0,036	0,050
Age	-0,058	0,003	-20,635	0,000	-0,063	-0,052
Boy or Girl	-0,531	0,013	-40,126	0,000	-0,557	-0,505

a. Dependent Variable: Health Complaints

A multiple linear regression was conducted to predict health complaints from vigorous physical activity (VPA), age and gender. The overall regression was statistically significant,  $F(3, 17171) = 836.417$ ,  $p < 0.001$ , and accounted for approximately 12.8% of the variance in health complaints ( $R^2 = 0.128$ , Adjusted  $R^2 = 0.127$ ). VPA was a significant positive predictor of health complaints ( $B = 0.043$ ,  $SE = 0.004$ ,  $t = 12.034$ ,  $p < 0.001$ ). This suggests that for each additional unit of vigorous physical activity, the frequency of health complaints decreases by 0.043 units. The Durbin-Watson statistic was 1.553, indicating no significant autocorrelation in the residuals.

## Somatic and psychological complaints separately

Table 6 - Somatic and Psychological complaints

Model	Unstandardized		t	Sig.	95.0% Confidence	
	Coefficients				Interval for B	
	B	Std. Error			Lower Bound	Upper Bound
a. Dependent Variable: mean somatic complaints						
A (Constant)	5,618	0,053	105,271	0,000	5,513	5,722
MVPA	0,027	0,003	8,080	0,000	0,021	0,034
Age	-0,068	0,003	-23,484	0,000	-0,074	-0,063
Boy or Girl	-0,523	0,014	-37,916	0,000	-0,550	-0,496
a. Dependent Variable: mean somatic complaints						
B (Constant)	5,543	0,056	98,530	0,000	5,433	5,653
VPA	0,033	0,004	8,915	0,000	0,026	0,041
Age	-0,066	0,003	-22,570	0,000	-0,072	-0,061
Boy or Girl	-0,518	0,014	-37,487	0,000	-0,546	-0,491
a. Dependent Variable: mean somatic complaints						
C (Constant)	4,880	0,062	79,133	0,000	4,759	5,001
MVPA	0,040	0,004	10,068	0,000	0,032	0,047
Age	-0,053	0,003	-15,806	0,000	-0,060	-0,047
Boy or Girl	-0,553	0,016	-34,690	0,000	-0,584	-0,522
a. Dependent Variable: mean psico complaints						
D (Constant)	4,737	0,065	72,928	0,000	4,610	4,864
VPA	0,053	0,004	12,209	0,000	0,044	0,061
Age	-0,050	0,003	-14,625	0,000	-0,056	-0,043
Boy or Girl	-0,543	0,016	-33,986	0,000	-0,574	-0,511
a. Dependent Variable: mean psico complaints						

**Table 6** shows a multiple linear regression to predict psychological and somatic health complaints separately from VPA, MVPA, age and gender. The results show that both MVPA and VPA are associated with fewer somatic complaints (models A and B), suggesting that for each additional unit of MVPA and VPA, the frequency of somatic complaints decreases by 0.027 and 0.033 respectively, with  $p < 0.001$ . The same reduction occurs for psychological complaints, suggesting that for each additional unit of MVPA and VPA, the frequency of psychological complaints decreases by 0.040 and 0.053, respectively, with  $p < 0.001$ .

## Discussion

This study examined the association between physical activity and mental health in adolescents, with a particular focus on the relationship between two different levels of physical activity intensity and life satisfaction and health complaints as key indicators of adolescents' mental health. In today's society, where adolescent mental health issues are becoming increasingly prevalent, investigating these relationships is crucial. By using the dual factor model, both the positive and negative dimensions of mental well-being were assessed. The primary finding of this study confirm our hypotheses: higher levels of moderate-to-vigorous physical activity (MVPA) and vigorous physical activity (VPA) were both associated with higher life satisfaction and fewer health complaints. Additional analyses showed that the association was found to be slightly stronger for psychological complaints than for somatic ones, with VPA showing a stronger relationship than MVPA. Nevertheless, while many of these effects were statistically significant, it is important to note that the magnitude of these effects was relatively small. For example, engaging in an additional day of MVPA or VPA led to only modest improvements in life satisfaction or reductions in health complaints. Yet, our results are aligned with the results from Khan et al. (2021) and Molcho et al. (2021), which also found positive relationships between physical activity and life satisfaction, as well as inverse associations with health complaints. Other studies, such as those of Zhang and Chen (2019) and Lábiscsák-Erdélyi et al. (2022) also support the link between higher physical activity levels and better mental health outcomes, including happiness and life satisfaction. Our results showed slightly stronger associations for VPA than for MVPA, with increased life satisfaction and fewer health complaints. These results are aligned with Khan et al. (2021), who reported a dose-dependent relationship between VPA and life satisfaction; however, the evidence of Khan et al. (2021) suggests that daily participation in VPA may be associated with a slight increase in health complaints, which raises questions about the potential limits of vigorous activity for well-being. It would be beneficial for future research to examine whether there is an upper limit to the intensity of physical activity, or if different types of physical activity can lead to these negative outcomes, where an increased prevalence of health complaints, become more likely.

However, the existing literature doesn't reach a consensus on the intensity of physical activity – either MVPA or VPA – and sometimes even light physical activity, that is most optimal for mental health benefits. Noting that VPA is not a different intensity, but a subset of the heaviest physical activity, within the levels of MVPA, there is no “one size fits all” and performing any

physical activity is better than none (Bull et al., 2020), however we may benefit from incorporating a combination of different intensities (Poitras et al., 2016). The study conducted by Noetel et al. (2024), despite being conducted in adults, is a relevant systematic review and network meta-analysis of randomised controlled trials assessing the effectiveness of exercise in the treatment of major depressive disorder, compared with psychotherapy, antidepressants, and control conditions. The effect of exercise appears to be directly proportional to the intensity prescribed. With regard to the impact of physical activity in studies with an intervention programme design, the work of Hale et al. (2023) and Rodriguez-Ayllon et al. (2019) in adolescents indicates that physical activity can play a role in positive measures of mental health, including improved quality of life, self-esteem and well-being. However, the evidence is less clear regarding the psychological ill-being characteristics. Although MVPA guidelines is frequently more emphasised in public health guidelines, as generally low risk and an effective method for improving mental and physical well-being, this study suggests that VPA may offer slightly more pronounced mental health benefits in adolescents. Nevertheless, further research is required to understand how physical activity benefits young people and to clarify the mechanisms that underpin these effects on mental health. The findings from Doré et al. (2020) and Lubans et al. (2016) provide valuable insights into the diverse mechanisms that could mediate this association: apart of demographic and individual factors there are – psychological factors, such as enhanced self-esteem and physical self-perceptions; social aspects, including peer support; or even neurobiological responses like endocrine secretion and neuroplasticity, concluding that all play a role and a lot of hypotheses are worth of investigation.

Although it was not specifically the aim of this thesis to investigate differences in physical activity and mental health according to sex and age, it can be relevant to also have a look at the descriptive statistics conducted within this study. Boys and younger adolescents reported higher life satisfaction and lower health complaints than girls and older adolescents. This is consistent with the findings of previous HBSC – based studies (Cosma et al., 2023) and also the Flemish region (Dierckens, 2023) and other literature measuring a positive mental health outcome, such as happiness, quality of life (Villafaina et al., 2021). Moreover, boys and younger adolescents also reported higher levels of MVPA and VPA. This might suggest that particularly girls and older adolescents, who are at a heightened risk of exhibiting lower levels of physical activity and poorer mental health outcomes and might benefit from targeted interventions. For example, the intervention programme “Girls Active” (Gorely et al., 2019) tries to foster girls and young women on participation in sports and physical activity. This result aligns with previous

literature from both international (Dumith et al., 2011; Rakić et al., 2024) and Flemish contexts (Dierckens, 2023).

In terms of meeting the recommended WHO guidelines, it was found that only 20.8% of the adolescents of this study adhere to the guidelines of at least 60 minutes per day for MVPA. In this case, on MVPA, the most prevalent method of assessing physical activity levels, this outcome is unsurprising, given that international studies and reports from the Flemish region also indicate that only 20% of adolescents meet the recommended guidelines. However, it should be noted that the old guidelines for MVPA were used, as those guidelines were available at the time of data collection. Current WHO guidelines stipulate that adolescents should engage in "an average of 60 minutes per day". It is also recommended that vigorous- intensity aerobic activities, as well as those that strengthen muscle and bone, should be incorporated at least 3 days a week (Bull et al., 2020). In this study 61.5% of participants assumed the practice of VPA 3 or more days a week.

In addition to statistical analyses, it is essential to reflect on the broader context of physical activity during adolescence. Structured physical activity, often in the form of organized sports, offers numerous benefits, including enhanced physical fitness and social integration. The sports community has the potential to enhance teamwork, creation of moral values, self-esteem and sense of belonging (Malina et al., 2004). However, the pressure to perform, competition stress, excessive full schedules, and early specialization, can also have an impact on overall well-being of young athletes, especially when pedagogical issues are not properly managed. This is where free play physical activity becomes especially important. The esteemed Portuguese Professor Carlos Neto offers a compelling perspective on this topic. In contrast to structured physical activities, free play enables children and adolescents to engage in spontaneous and creative exploration of movement, thereby facilitating motor development and self-regulation. There are opportunities regarding sport practice that can lead to a positive or negative impact on mental health and well-being. It's necessary to be able to stay on the better side of the equation. It is only through the efforts of devoted educators, supportive families, and dedicated healthcare professionals that the potential benefits of physical activity during the early stages of life can be fully realised.

## **Strengths and limitations**

The main strengths of this study lie in its large representative sample of 17175 adolescents as well the use of standardized and validated data collection procedures from the HBCS study ensuring the reliability of the information, which provides valuable insights into the relationship between physical activity and mental health outcomes within the Flemish context. The use of the dual-factor model allows for a more comprehensive understanding of the association of physical activity on both positive and negative mental health dimensions.

However, there are limitations to consider. The use of self-reported data for both physical activity and mental health may introduce bias, as participants may overestimate their physical activity levels or underreport their health complaints. Although objective measures, such as accelerometers, would provide more accurate data, they are often not feasible to conduct on large-scale epidemiological studies, such as the HBCS survey. Furthermore, the cross-sectional design of this study does not allow the drawing of causal conclusions. While the associations between physical activity and mental health are compelling, longitudinal studies would be required to infer a cause-and-effect relationship. Another potential issue is the way physical activity was reported. Including separate questions for moderate and vigorous activity separately, could have allowed for a more accurate comparison between them. Furthermore, the incorporation of low-intensity physical activity or sedentary time information would have provided a more comprehensive understanding. Age and gender were employed as covariates, However, it would have been interesting to include those variables as moderators too, to assess whether the association between physical activity and mental health differs according to sex and age. Other HBSC studies (Cosma et al., 2023) have also identified other confounders to add as covariates to the analyses, such as family affluence, self-esteem, and screen time behaviours. In future research, additional attention might be given to selecting all relevant confounders.

## **Conclusion**

This study reinforces the positive association between physical activity and mental health in adolescents, highlighting the potential benefits of VPA on higher levels of life satisfaction and fewer health complaints, especially psychological complaints.

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