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Objective and Subjective Physical Activity Levels in Austrian Middle School Students

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Abstract

Background: Insufficient physical activity is considered a major threat to future public health as many children and adolescents do not engage in the recommended amount of physical activity (PA), despite the well-documented health benefits. The evaluation of ongoing efforts as well as future intervention strategies, however, requires an accurate assessment of PA. **Aim:** The present study, therefore, examined differences between objectively and subjectively determined PA in 36 Austrian adolescents (52.8% male; 13.5 ± 0.5 years of age). **Methods:** Time spent in moderate-to-vigorous PA (MVPA) and time spent sedentary was assessed with a wrist-worn accelerometer (GENEActive) that was worn for 7 consecutive days. Self-reported sleep duration was subtracted from total sedentary time in order to obtain sedentary time during waking hours. Participants also completed the short version of the International PA questionnaire (IPAQ) at the end of the objective measurement, which assesses time spent in MVPA and sitting time during the previous week. **Results:** Objective and subjective data showed that adolescents spent the majority of their time sitting or in sedentary pursuits. Self-reported MVPA was more than double the amount of the objectively determined time spent in MVPA ($p < 0.01$). Accordingly, the majority of adolescents (88.9%) met PA recommendations based on self-report, while only 22.2% were considered sufficiently active when objective PA measurements were used. There were also significant sex differences with higher MVPA as well as lower sedentary time in boys compared to girls ($p < 0.01$). **Conclusions:** These results highlight the difficulty to accurately determine PA via questionnaire, which may be attributed to irregular PA patterns in youth. Accordingly, subjective measurements may need to be combined with objective methods in order to enhance the accuracy of PA assessments. The low levels of objectively deter-

mined PA, particularly in girls, further emphasize the need for continued efforts to ensure an adequate amount of PA in youth.

Keywords

Adolescents, Moderate-to-Vigorous Physical Activity, Sitting Time, Sedentary Behavior, Accelerometry, Physical Activity Questionnaire

1. Introduction

The importance of physical activity (PA) for the development and general well-being of children and adolescents has been well documented (Donnelly et al., 2016; Ortega et al., 2008). Low PA has been associated with poor physical fitness and increased body weight as well as an increased risk for cardio-vascular and metabolic diseases (Kyu et al., 2016; Lee et al., 2012). Given the associated costs, physical inactivity is also a significant economic burden; in Germany, for example, 5% of the total health care costs are attributed to physical inactivity (CEBR, 2015) and Lee et al. (2017) argue that US $ 16.6 billion in direct medical costs and US $ 23.6 billion in lost productivity could be avoided if 75% of children in the US would exercise 3 times a week. Nevertheless, a majority of children and adolescents are insufficiently active and their behavioral pattern has been characterized by a predominantly sedentary lifestyle (Finger et al., 2018; Tremblay et al., 2016; Van Hecke et al., 2016; Guthold et al., 2020). It is also noteworthy that recent data shows higher levels of insufficient PA in low-income countries compared to high income countries (Guthold et al., 2020). Nevertheless, German data also shows that less than 20% of 11- to 17-year-old adolescents meet current PA recommendations of 60 minutes of moderate-to-vigorous PA (MVPA) (26), which is similar to global levels of insufficient PA of 81.% (Guthold et al., 2020).

Given the health implications of PA, an accurate assessment of PA is necessary to accurately evaluate the efficacy of various PA intervention strategies along with the association of PA and specific health outcomes (Müller, Winter, & Rosenbaum, 2010). Even though PA is defined as any bodily movement that increases energy expenditure (Caspersen, Powell, & Christenson, 1985), it reflects a multi-dimensional behavior that is characterized by duration, intensity and type (e.g., endurance vs. Strength activities) (Bull et al., 2020). The complexity also makes an accurate assessment of PA in its totality a challenging task (Prince et al., 2008). Subjective methods, such as questionnaires or diaries as well as objective methods that include pedometers, accelerometers and a combination of physiological measurements (e.g., heart rate) with accelerometry are commonly used to determine PA in various populations and settings (Müller et al., 2010). At this time there is, however, no single method that can precisely measure all aspects of PA in a natural setting and both objective and subjective measurements remain widely used in PA research. Despite the benefits of objective PA

assessments, there exist different protocols regarding placement and data processing, which could affect comparability of results (Migueles et al., 2019; Poitras et al., 2016). Aguilar-Farias et al. (2021) further pointed out that there remains a limited understanding of the exchangeability between objective and subjective PA data across different countries.

The present study, therefore, examined the differences in self-reported and objectively determined PA levels in Austrian adolescents. Specifically, differences in MVPA are explored as current PA guidelines focus predominantly on MVPA (Janssen, 2007; Piercy et al., 2018). In addition, differences in time spent sedentary were examined due to the independent association of excess sedentary time with various health outcomes (Owen et al., 2010).

2. Materials and Methods

Two middle schools in the Federal State of Tyrol, Austria, were randomly selected for participation. Due to the limited number of accelerometers available only students from 8th grade were included in the study, which resulted in 92 eligible participants between 13 and 14 years of age. Parents provided written informed consent and oral assent was obtained from participants prior to data collection. The study protocol was approved by the Institutional Review Board of the University of Innsbruck, the Tyrolean school board and the participating schools.

Data collection occurred in Mai 2017. The participant's body weight and height were measured according to standard procedures during a school visit with children wearing gym clothes and barefoot. Specifically, body weight was measured to the nearest 0.1 kg with a calibrated digital scale (SECA® 803, Hamburg, Germany) and height was measured with a portable stadiometer (SECA® 217, Hamburg, Germany) to the nearest 0.1 cm. Subsequently, body mass index (BMI) was calculated (kg/m^2) and converted to BMI percentile based on German reference values with the 90th percentile as cutpoint for overweight/obesity (Kromeyer-Hauschild et al., 2001).

2.1. Objective Assessment

PA was assessed via a wrist-worn accelerometer (ACC), which also includes a light and temperature sensor (GeneActiv, Activinsights®, Kimbolton, UK). The device has been shown to provide valid and reliable information (Esliger et al., 2011; Pavey et al., 2016). Participants wore the accelerometer continuously for one week on the left arm. This was the non-dominant arm of all participants, which has been shown to provide more accurate results when wrist-based accelerometry is used (Montoye et al., 2016). Data was collected at a frequency of 10 Hz with a 10 second EPOC length. Time spent in MVPA was determined via the accompanying software (GENEActiv, version: 2.2, ActivInsights Ltd. 2010) (Schaefer et al., 2014). As participants also reported the time they went to bed and got up in the morning sedentary time was calculated as total recorded sedentary time minus sleep time. Daily time spent sedentary and in MVPA was subsequently av-

eraged over the entire week for the comparison with the subjective PA assessment.

2.2. Subjective Assessment

PA questions were based on the International Physical Activity Questionnaire – Short Form (IPAQ-SF), which is a commonly used assessment tool to determine PA and sitting time over a period of one week (Craig et al., 2003). Specifically, participants reported the number of days they engaged in moderate PA (MPA) and vigorous PA (VPA) as well as walking and the average amount of time spent in these activities per day they engaged in during the previous week. Total time spent in MPA, VPA and walking were subsequently calulated (number of days x daily PA time) and divided by 7 to obtain average daily values. MVPA was calulated as the sum of MPA and VPA. In addition, daily sitting time during the previous week was reported (Maddison et al., 2007). Participants completed the questionnaire when the accelerometer was returned; accordingly, the subjective report fell in the same time as the objective measurement.

2.3. Statistical Analyses

Data was checked for normal distribution and values are reported as means with SD for the total sample and separately for boys and girls, unless prevalence is shown. The association between IPAQ and accelerometry data was initially checked via Spearman correlation with the strength of the association being evaluated as strong ($r_s > 0.5$), moderate ($0.5 \geq r_s \geq 0.3$) or weak ($0.3 > r_s > 0.1$) for positive and negative correlation coefficients (Cohen, 1988). Additionally, differences between objectively determined and self-reported time spent in MVPA as well as sedentary behavior were examined via Bland-Altman plots and dependent t-tests. Eta squared (η^2) was used to determine effect size with values above 0.01, 0.06 and 0.14 being interpreted as small, medium or large effect, respectively (Cohen, 1988). All statistical analyses were calculated with SPSS 26.0 and the significance level was set at $p < 0.05$.

3. Results

Of the 92 eligible participants 38 did not provide parental consent, which resulted in a sample of 54 adolescents for data collection. Two participants reported technical difficulties and 16 students did not wear the armband consistently. Accordingly, valid data was provided by 36 participants (47.2% female), which were included in the analyses. There were no differences in age, body weight and BMIPCT between boys and girls. Boys, however, were significantly taller than girls. Boys also displayed higher PA levels than girls. Objective sedentary time was higher in girls compared to boys but there was no sex difference in subjective sitting time (**Table 1**).

There was a moderate correlation between IPAQ and ACC measurements for MVPA ($r_s = 0.454$, $p < 0.01$) while there was no significant association between

reported sitting time and objectively measured sedentary time. Dependent t-tests further showed significantly higher self-reported MVPA compared to MVPA based on ACC ($p < 0.01$) with medium effect size ($\eta^2 = 0.07$). The difference of 56.5 ± 29.7 min/day in MVPA, however, reflects more than double the amount of self-reported MVPA compared to objectively measured MVPA. Self-reported sitting time, on the other hand, was 186.2 ± 117.9 min/day lower than objectively measured total sedentary time ($p < 0.01$, $\eta^2 = 0.08$), which reflects a difference of 75% (Figure 1).

Table 1. Descriptive characteristics for the total sample and separately for boys and girls. Values are mean ± SD.

	Total Sample N = 36	Girls only N = 17	Boys only N = 19
Age (years)	13.5 ± 0.5	13.5 ± 0.5	13.5 ± 0.5
Height (cm)**	167.3 ± 6.4	164.1 ± 5.3	170.2 ± 6.0
Weight (kg)	54.2 ± 7.6	53.3 ± 9.3	55.0 ± 5.7
BMI percentile	49.5 ± 24.9	50.9 ± 30.1	48.3 ± 20.0
IPAQ Sitting (min/d)	565.0 ± 73.3	573.5 ± 86.7	557.4 ± 60.3
IPAQ MVPA (min/d)**	105.7 ± 35.0	82.6 ± 25.5	126.4 ± 29.2
ACC sedentary (min/d)**	751.2 ± 91.0	796.4 ± 88.6	710.8 ± 73.8
ACC MVPA (min/d)**	49.2 ± 15.7	39.8 ± 13.3	57.7 ± 12.9

ACC: accelerometer measured intensities; IPAQ: self-reported behavior; MVPA: moderate-to-vigorous physical activity; **significant sex difference, $p < 0.01$.

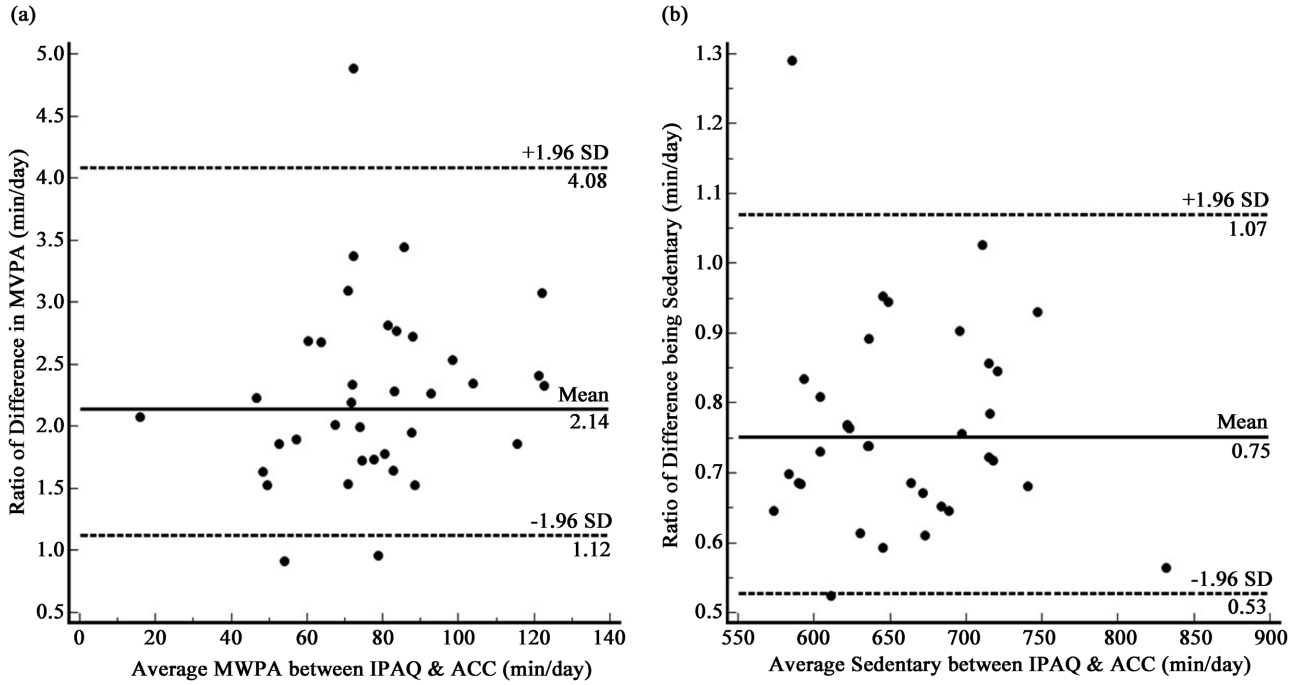

Figure 1. Bland-Altman-Plot showing the ratio of the difference between IPAQ and accelerometry (mean and limits of agreement) for MVPA (a) and sedentary time (b).

These differences were also reflected by the number of participants considered sufficiently active. Based on IPAQ 88.9% of the participants (100% boys, 76.5% girls) met current PA guidelines of 60 min/day of MVPA while only 22.2% (42.1% boys, no girls) were considered sufficiently active based on the objective assessment of MVPA.

4. Discussion

The present study examined MVPA and sedentary behavior via accelerometry and by questionnaire in 13- to 14-year-old middle school students. Independent of the measurement being used, the participants spent the majority of their time in sedentary pursuits and PA levels were lower in girls compared to boys. Self-reported PA levels, however, were significantly higher than accelerometry-based PA. In fact, participants reported more than double the amount of objectively determined PA, which was also reflected by the prevalence of participants being considered sufficiently active. Based on self-report almost 90% of the participants would have been considered sufficiently active while less than 25% of participants were meeting PA recommendations of 60 minutes/day when MVPA was assessed via accelerometry. Self-reported sitting time, on the other hand, was lower than accelerometer-determined sedentary time. Given the wide-spread use of questionnaires, particularly in epidemiological studies it is, therefore, possible that current estimations of PA in youth are higher than is actually the case.

The overestimation of PA based on questionnaires has been documented in previous studies (Craig et al., 2003; De Cocker et al., 2007; Gaede-Illig et al., 2014; Lee et al., 2011). Due to the low cost, questionnaires, nevertheless, remain a popular tool in epidemiological studies. Given the important implications of PA for future health (Chaput et al., 2020; Lee et al., 2012), such results can have significant implications for policy decisions. Based on questionnaire data, it could be argued that a majority of Austrian adolescents are sufficiently active and no further efforts are needed to promote PA in youth. Objective data, on the other hand, showed that none of the girls and less than half of the boys are sufficiently active. These results, which are consistent other studies (Hallal et al., 2012; Kettner et al., 2012; Manz et al., 2014), clearly emphasize the need for a stronger commitment to the promotion of PA, particularly in girls. The observed differences in PA between boys and girls are also consistent with previous research (Junger et al., 2018). Sex differences in PA have been attributed to differences in activity preferences and opportunities for engagement in different forms of PA (Vasickova et al., 2013). Further, social aspects need to be considered as the importance of PA among peers is an important correlate of PA (Sterdt et al., 2014; Martins et al., 2017). Additionally, self-efficacy and body image have been addressed as correlates of PA particularly in girls (Nalecz et al., 2012; Sallis et al., 2000). Girls generally show a lower self-efficacy and higher levels of negative body image compared to boys, which has been associated with lower PA and

higher sedentary time (Añez et al., 2018).

Low PA levels in youth have been commonly attributed to high sedentary time at school and during home work as well as the increasing popularity of electronic devices (e.g., phones, computer) during leisure time (Kaiser-Jovy, Scheu, & Greier, 2017; Manz et al., 2014). A large amount of youth also rely on motorized transportation to get to school and recreational activities rather than using modes of active transportation.

Accordingly, objective measures of sedentary time exceeded 12 hours/day, with a larger amount of sedentary time in girls compared to boys. A high amount of sedentary time, however, has been associated with various determinetal health effects, independent of PA (Owen et al., 2010). Specifically, sitting time above 8 hours/day, which was exceeded based on IPAQ and accelerometry measurements, has been associated with increased morbidity and mortality (Koster et al., 2012; Patel et al., 2010; Schmid, Ricci, & Leitzmann, 2015; van der Ploeg et al., 2012) and sitting for more than 10 hours/day was associated with an increased risk for cardiovascular disease (Chomistek et al., 2013). These detrimental effects, however, can be attenuated with engagement in MVPA; according to recent research a minimum of 2.5 minutes of MVPA per hour of sitting time can reduce the increased mortality risk associated with high sitting time in adults (Chastin et al., 2021). As various lifestyle habits are established during adolescence (Gordon-Larsen, Nelson, & Popkin, 2004) it is critical to implement strategies that reduce sedentary time and increase PA in youth. Intervention efforts should particularly target girls, as they have been shown to spend more time in sedentary pursuits and less time in MVPA (Drenowatz & Greier, 2019; Hallal et al., 2012).

Some limitations of the present study, however, need to be considered when interpreting the results. A major limitation of the study is the small sample size due to the limited number of accelerometers. In addition, data collection occurred in only two schools and included only students from one grade, which limits the genearlizability of the results. There was also no information on biological maturation, which has been shown to affect PA (Moore et al., 2020). The objective and subjective assessment over the same time period, on the other hand, is a strength of this study.

5. Conclusion

Taken together, the results of the present study highlight the difficulties of adolescents to accurately report their PA and sedentary time. This may be attributed to their irregular activity patterns (Sirard & Pate, 2001). In addition, it should be considered that objective and subjective measurements are not always assessing the same concept (e.g., sedentary time vs. screen time) and, therefore, may not be interchangeable. Rather, objective and subjective measurements such as data from mobile apps, could be used as complementary tools in PA research. Given the low PA levels of adolescents, as shown in this study and previous research

(Hallal et al., 2012; Manz et al., 2014), it is crucial to obtain accurate data on PA levels in youth. This will allow us to enhance our understanding of correlates of PA in youth and facilitate the development and evaluation of intervention strategies targeting an active lifestyle in adolescents.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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