Does it fit better? Measures of physical activity among adolescents in relation to health indicators

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Background: Measuring physical activity (PA) is one of the pillars of successful health promotion; however, we struggle to find a tool enabling the identification of risk groups. The current standard approach of assessing moderate-to-vigorous physical activity (MVPA) every day does this inadequately. The aim of this study is to explore whether three other indicators of adolescents' PA can identify such risk groups in a better way.
Methods: We used data on 888 11- to 15-year-old adolescents (mean age = 13.5, 56% boys) from the Health Behaviour in School-aged Children study conducted in 2018 in Slovakia. Sufficient PA was indicated by the following four indicators: (i) MVPA every day, (ii) MVPA 5–7 days a week, (iii) engagement in organized sports (team or individual) and (iv) combining MVPA 5–7 days a week and engagement in organized sports. We used binary logistic regression analysis to assess the association of various indicators of adolescents' PA with body composition, cardiovascular fitness and self-rated health (SRH), considering age and gender. **Results:** Being active based on various indicators was associated with better health outcomes, with the strongest associations for the indicator combining MVPA 5–7 days a week and engagement in organized sports. The only exceptions were the non-significant associations of active adolescents (being active 5–7 days per week or engaged in organized sports) with cardiovascular fitness and SRH. **Conclusions:** Measuring PA using an indicator that combines MVPA 5–7 days a week and engagement in organized sports is the most valid using three health indicators as criteria.

Introduction

Physical activity (PA) in adolescence is one of the decisive factors in maintaining and promoting health and an indispensable universal means of disease prevention.[1] It is important to note that an insufficient level of adolescents' PA is a major problem, reaching 81% of this population worldwide.[2] It is well known that PA can lead to a positive cascading effect in various areas of adolescents' health.[3] As noted by Alqahtani et al.[4] and Aryeetey et al.,[5] adolescents who reported higher participation in PA were more likely to be of normal weight. In addition, physically active adolescents have significantly better cardiovascular fitness levels than inactive ones.[6] According to Matin et al.[7] and von Rosen and Hagströmer,[8] sufficient adolescents' PA is associated with good or excellent self-rated health (SRH). Studies examining associations between adolescents' PA, body composition, cardiovascular fitness and SRH are limited and generally confined to measured time spent in moderate-to-vigorous physical activity (MVPA).

The World Health Organization (WHO) recommends that children and adolescents should do 'at least an average of 60 min/day of moderate-to-vigorous intensity, mostly aerobic, PA, across the week'.[9] A single-item self-reported question on MVPA during the preceding seven days is used widely in the WHO Collaborative Cross-National Health Behaviour in School-aged Children (HBSC) study as a measure of meeting international PA recommendations.[10] Aubert et al.[11] highlighted that the current state of surveillance methods of adolescents PA does not match its public health importance. First, fewer than one in five adolescents meet the WHO global PA

recommendations,[12] meaning that we have a large group not meeting them. This large group is a combination of adolescents who are less active and who are inactive, making this a heterogeneous target group for our public health messages. Second, it seems taking into account only reported time spent on PA leads to neglecting the importance of organized sports activities led by qualified adults in reaching a sufficient level of PA and the development of physical literacy.[13–15] Directions to improve the measurement of PA for public health purposes could therefore include different domains of PA for adolescents, such as MVPA and engaging in organized sports. This could provide an important and affordable solution for appropriate self-reported measurement of adolescents' PA, which also might be used for public health policy and prevention.

Therefore, we assessed how another approach to adolescents' PA (a less strict cut-off for MVPA, engagement in organized PA, or combining MVPA and engaging in organized sports) might lead to a better assessment of PA in youth. The aim of this study is to explore whether three other indicators of adolescents' PA identify such risk groups in a better way in terms of prevalence and association with health indicators (body composition, cardiovascular fitness and SRH).

Methods

Sample and procedure

We used data on 888 adolescents (mean age = 13.5, 56% boys; standard deviation = 1.30) from the HBSC study conducted in 2018 in

Slovakia. These constituted a random sample of about 10% of all children participating in the HBSC study. We used a three-step sampling to obtain a representative sample. In the first step, 140 larger and smaller elementary schools located in rural as well as in urban areas from all regions of Slovakia were asked to participate. These were randomly selected from a list of all eligible schools in Slovakia obtained from the Slovak Institute of Information and Prognosis for Education. The school response rate was 77.9%. In the second step, we obtained data from 8405 adolescents from the fifth to ninth grades of elementary schools in Slovakia in the target group of 11- to 15-year-olds. In the third step, 10% of elementary schools were randomly selected from the total sample of the HBSC study for anthropometric measurements (body height, body weight and body composition).

The study was approved by the Ethics Committee of the Medical Faculty at P. J. Safarik University in Kosice (16N/2017). Parents were informed about the study via the school administration and could opt out if they disagreed with their child's participation. Participation in the study was fully voluntary and anonymous with no explicit incentives provided for participation.

Measures

We measured PA using four indicators: (i) the routine one, i.e. MVPA every day, and then three additional alternative ways, i.e. (ii) MVPA 5–7 days a week, (iii) engagement in organized sports and (iv) combining MVPA 5–7 days a week and engagement in organized sports. 'MVPA' was measured by an item asking adolescents about the number of days over the past week that they were physically active for a total of at least an average of 60 min per day. The question was preceded by an explanatory text that defined moderate-to-vigorous activity as 'any activity that increases your heart rate and makes you get out of breath some of the time', offering examples of such activities (running, inline skating, cycling, dancing, swimming, ice skating etc).[16] Responses could vary from 0 to 7 days per week.

(1) 'MVPA every day' classified as 'active'—PA for 7 days vs. 'inactive'—less (from 0 to 6 days), based on WHO recommendations.[17]
(2) 'MVPA 5–7 days a week' classified as 'active'—PA for 5–7 days a week vs. 'inactive'—less (from 0 to 4 days).
(3) 'Engagement in organized sports [organized leisure-time activities OLTA]' was measured by an item from the HBSC survey with the following question: 'Are you doing any of these organized activities in your free time?' with response categories 'yes' and 'no'.[16] The HBSC survey presents six categories of organized activities and respondents were asked to indicate the type of activity in which they participated. In this research, we used only two categories: (i) organized team sport activities (e.g. football, basketball and volleyball); and (ii) organized individual sport activities (e.g. tennis, gymnastics and karate).
(4) 'Combining MVPA 5–7 days a week and engagement in organized sports' yielded the following three categories: (i) inactive: adolescents who were active <5 days per week and were not engaged in organized sports, (ii) active: adolescents who were active 5–7 days per week or were engaged in organized sports and (iii) very active: adolescents who were active 5–7 days per week and also were engaged in organized sports.[18]

We used three measures as criteria, i.e. body composition, cardiovascular fitness and self-rated health. We measured 'body composition' using body fat percentage (%) as determined by Bioimpedance Body Composition Analysis (BIA) with an InBody 230 (Biospace Co., Ltd.). The analysis was carried out according to the manufacturer's instructions.[19] Adolescents were instructed prior to measurement to dress in a t-shirt and trousers or skirt. The starting weight was set to −0.5 kg, considering that we weighed the adolescents in their underwear. Boys

and girls with a proportion of body fat of over 25% and 30%, respectively, were considered to be overweight or obese.[20,21]

Level of 'cardiovascular fitness' was assessed using the Ruffier index (RI) calculated from the measured values of pulse frequency at rest before the Ruffier test (P0), after performing 30 squats for 45 s under the sound of a metronome (P1) and after 1 min of rest in a sitting position (P2). The Ruffier test was modified in the method of measuring the pulse rate (we replaced the original palpation measurement with measurements using SUUNTO DUAL pulse rate monitors) and in the length of physical and mental rest before the test (from the original 30 min to 3 min of sitting for reasons of time). We substituted the measured values of the pulse frequency into the formula: $RI = ((P0 + P1 + P2) − 200)/10)$ and dichotomized the level of cardiovascular fitness into two categories—'sufficient' (included 'excellent', 'good', 'average' and 'below average' levels) and 'insufficient' (included 'very poor' level).[22]

'Self-rated health' (SRH) was assessed by the HBSC question asking: 'Would you say your health is……?' with four possible answers—'poor', 'fair', 'good'/'excellent'.[16] We dichotomized the answers into two categories—'other' and 'excellent'.[23]

'Demographic data' (age and gender) were collected using single HBSC questions.[16] We dichotomized age into two categories—'younger' (11 and 12 years old) and 'older' (from 13 to 15 years old).

Statistical analyses

First, we described the sample using descriptive statistics. Next, we assessed whether the other three indicators of adolescents' PA identified risk groups in a better way in terms of prevalence and in association with health indicators (body composition, cardiovascular fitness and SRH). We did so by first computing prevalence and second by assessing the association of the four indicators of PA with body composition, cardiovascular fitness and SRH using binary logistic regression models (enter model) adjusted to age and gender, leading to odds ratios (ORs) and 95% confidence intervals. All analyses were performed using IBM SPSS Statistics 21 for Windows.

Results

Background characteristics

Of our respondents, 22.7% were overweight or obese, 74.4% had a sufficient level of cardiovascular fitness and 72.8% had other than excellent SRH. A total of 61.1% of respondents were in older age group (13–15 years) and 56.0% were boys (table 1).

Prevalence of PA based on various indicators

Using MVPA every day (MVPA1), MVPA 5–7 days a week (MVPA2), engagement in organized sports (OLTA), and combining MVPA 5–7 days a week and engagement in organized sports yielded different prevalences of adolescents' PA. Only 20.2% of adolescents were active at least 60 min per each day, but 47.2% were so at least 5 days a week, and 63.3% were engaged in organized sports. The composite variable of PA identified 37.0% of adolescents as very active (being active 5–7 days per week and being engaged in organized sports), and 36.2% of adolescents as active (being active 5–7 days per week or being engaged in organized sports).

The association of various indicators of adolescents' PA with body composition, cardiovascular fitness and SRH

Adolescents' PA was significantly associated with all three health indicators, with ORs varying from 1.3 to 4.2 (figure 1); e.g. being active or being engaged in organized sports was associated with better health indicators. The indicator combining MVPA 5–7 days a week and engagement in organized sports had the strongest associations with health indicators. The only exceptions regarded

Table 1 Characteristics of the sample (*N* = 888, 11- to 15-year-old Slovak school-aged children, data collected in 2018)

Characteristic	*N* (%)
Body composition	
Normal weight	686 (77.3)
Overweight and obesity	202 (22.7)
Cardiovascular fitness	
Sufficient	661 (74.4)
Insufficient	227 (25.6)
SRH	
Excellent	241 (27.2)
Other	644 (72.8)
MVPA 1	
Active (7 days)	179 (20.2)
Inactive (0–6 days)	705 (79.8)
MVPA 2	
Active (5–7 days)	417 (47.2)
Inactive (0–4 days)	467 (52.8)
OLTA	
One or more OLTA	544 (63.3)
No OLTA	316 (36.7)
Adolescents' PA	
Very active	318 (37.0)
Active	311 (36.2)
Inactive	230 (26.8)
Age	
Younger (11–12 years old)	345 (38.9)
Older (13–15 years old)	543 (61.1)
Gender	
Boys	497 (56.0)
Girls	391 (44.0)

Note: MVPA, moderate-to-vigorous physical activity; OLTA, organized leisure-time activities; PA, physical activity; SRH, self-rated health; numbers of missing cases per variables: body composition—0; cardiovascular fitness—0; SRH—3; MVPA1/2—4; OLTA—28; adolescents' PA—29; age—0; gender—0.

the non-significant associations of 'active adolescents' (being active 5–7 days per week or being engaged in organized sports) with cardiovascular fitness and with SRH.

Discussion

We assessed how another approach to adolescents' PA [a less strict cut-off for MVPA, engagement in organized sports (team or individual), or combining MVPA and engaging in organized sports] might lead to better assessment of PA in youth. The prevalence of physically active adolescents varied from 22.7% to 61.1% based on various indicators of PA. Being active based on various indicators was associated with better health indicators, with associations being strongest for the indicator combining MVPA 5–7 days a week and engagement in organized sports. The only exception regarded the category 'active adolescents' (being active 5–7 days per week or being engaged in organized sports) which had no significant association with cardiovascular fitness and SRH.

The heterogeneity of the target group

Large variations in PA prevalence rates were found based on the different indicators. This may be due to single MVPA- or OLTA-based measures leading to the inclusion of a too heterogeneous group of adolescents in the target group, including adolescents who are less active and inactive. This heterogeneity can be explained by Ajzen's theory of planned behaviour, which links beliefs to behaviour.[24] According to Ajzen, the impact of past behaviour is reduced when intentions are strong and well-articulated, expectations are realistic and specific plans are made to realize the intention.[24] From this, it follows that a separate MVPA or OLTA may not be effective enough to identify groups of adolescents that deserve special attention. Moreover, regarding the added value of combining PA and OLTA, this also aligns with the previous research by Kleszczewska *et al.*,[25]
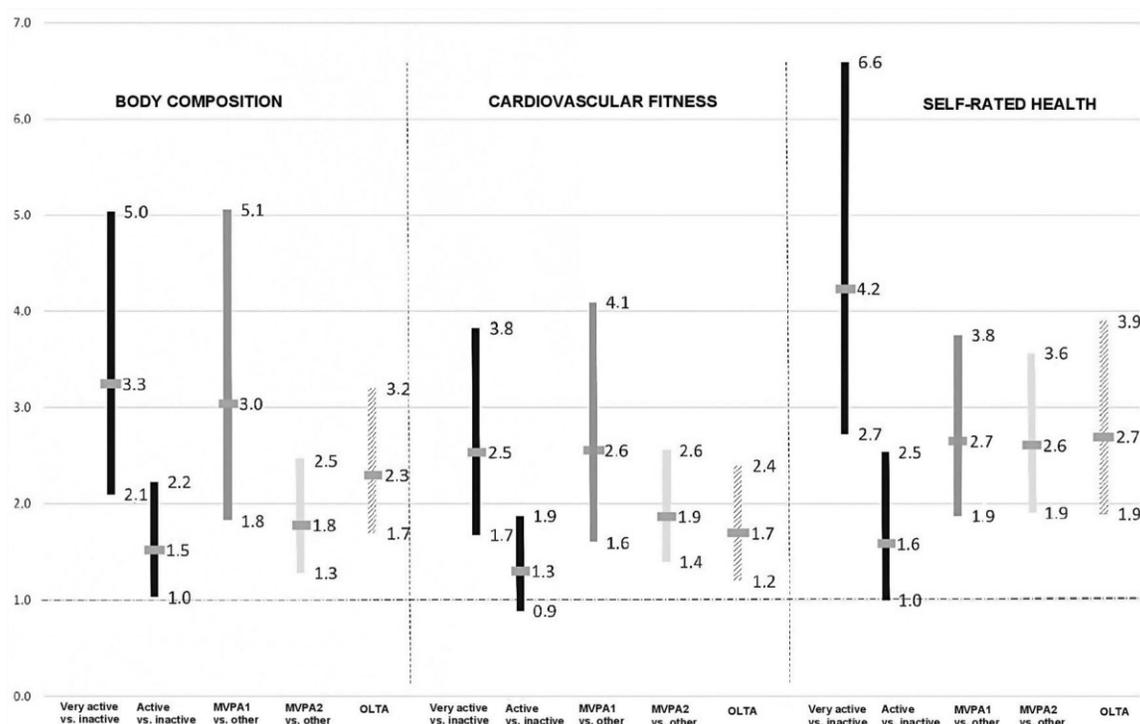

Figure 1 The association of various indicators of adolescents PA with body composition, cardiovascular fitness and self-rated health adjusted for age and gender: odds ratios and 95% confidence intervals resulting from binary logistic regression models

Note: PA, physical activity; MVPA, moderate-to-vigorous physical activity; MVPA1, moderate-to-vigorous physical activity every day; MVPA2, moderate-to-vigorous physical activity 5–7 days a week; OLTA, organized leisure-time activities; very active, being active 5–7 days per week and being engaged in organized sports; active, being active 5–7 days per week or being engaged in organized sports; inactive, being active <5 days per week and not being engaged in organized sports.

in which were used a combined PA index as predictor of health status (i.e. mental well-being). This index was based on the MVPA indicator, the VPA indicator (intensive PA) concerning leisure time activity, and two items concerning participation in organized sports activities (separately team and individual). In addition, it is important to highlight that our recommendations align with previous guidelines for young people, which were somewhat less stringent, by recommending accumulating 60 min of MVPA on most days of the week,[26] instead of 7-days-a-week MVPA in the current guideline.

Combining MVPA and OLTA adds

Our results showed the strongest association between the combination of MVPA 5–7 days a week and engagement in organized sports and the three health indicators, e.g. body composition, cardiovascular fitness and SRH. According to Kokko et al.[13] and Fröberg et al.,[14] adolescents who participated in organized sports had significantly higher total PA and more time spent on MVPA. This aligns with findings of a 3-year longitudinal study[27] that adolescents who regularly participated in at least 3 h per week of sports activities were more prone to avoid total and regional fat mass accumulation. It is important to note that WHO guidelines focus not only on the 'at least an average of 60 minutes per day of moderate-to-vigorous intensity, mostly aerobic, PA, across the week' but also indicate that children and adolescents 'should incorporate vigorous-intensity aerobic activities, as well as those that strengthen muscle and bone, at least 3 days a week'.[28] Moreover, a study of Sigmund et al.[29] on a sport-based intervention showed that long-term PA may also result in a notable reduction of obesity. Another explanation might regard physical literacy, which has become an increasingly influential concept in the past few decades. As noted by Bergeron et al.,[30] it is an adolescent's mastery of the basic set of motor skills that contributes to confidence and long-term involvement in PA and can help youth manage their weight and reduce health risks. In other words, combining MVPA and OLTA adds to the identification of groups at increased risk.

Strengths and limitations

The major strengths of this study regard its large, nationally representative sample of adolescents and the comparability of our data with the international data within the HBSC study. Another strength is that we used a composite variable enabling a multifactorial consideration of the phenomenon of PA in adolescents. Another potential strength is the use body composition and cardiovascular fitness, which represent objective measurements (using body fat percentage and the RI).

Some limitations should also be mentioned. A first limitation is that adolescents' PA and SRH were self-reported measures, making them prone to reporting bias. This is unlikely to explain the associations found but may have added some measurement error. A second limitation is that we did not collect information on the time frame and frequency of OLTA participation, which could have yielded more detailed information on prevalence and associations with the health indicators. A third limitation is the cross-sectional design of this study, which hinders conclusive inferences about causality. Therefore, our findings need to be confirmed in longitudinal studies.

Implications

Our findings contribute to the idea that combining MVPA and engaging in organized sports is a valuable approach for better assessment of PA among adolescents. In practice, this is relatively easy to measure, making it suitable for use in routine care. In addition, these new findings on adolescents show a need for additional research in younger age groups using the same health indicators as criteria to assess whether measures could be improved for these ages as well.

Conclusions

Measuring PA by an indicator combining MVPA 5–7 days a week and engagement in organized sports is most valid regarding three health indicator as criteria. Adolescents' PA needs to be done regularly and in an organized setting to have a positive impact on important health markers (such as body composition, cardiovascular fitness and SRH).

Funding

Key points

- The prevalence of physically active adolescents varied from 22.7% to 61.1% based on various indicators of physical activity (PA).
- Measuring PA by an indicator combining moderate-to-vigorous physical activity (MVPA) 5–7 days a week and engagement in organized sports is most valid regarding three health indicator as criteria.
- Combining MVPA and engaging in organized sports is a valuable and relatively easy to measure approach for better assessment of PA among adolescents.

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