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Physical activity of female children and adolescents based on step counts: meeting the recommendation and relation to BMI

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Summary

Study aim: the aim of this study was to assess the step counts of children and adolescents with different BMIs and to present the results in relation to the step count recommendation.
Material and methods: the study included data from 175 girls, aged 12–18 (45 participants from primary school, 69 participants from junior high school and 61 participants from high school). Voluntary participants were recruited from public schools in Poland. Step counts were measured using pedometers (Yamax Digi-Walker SW 701) over seven consecutive days.
Results: the recommended level of 12000 steps per day was achieved by only 14.9% of participants. The step counts performed by girls, especially at the primary school age, are currently insufficient. Participants' achievement of the recommended step count level correlated with a lower BMI.
Conclusions: few female children and adolescents are meeting daily step recommendations, which highlights the importance of school and community-based programmes designed to increase daily activity patterns.

Key words: Pedometers – Step counts – BMI – Girls – Children – Adolescents

Introduction

Physical activity (PA) is associated with health benefits irrespective of age [33], and physical inactivity is the fourth greatest risk factor of premature morbidity in the world [44]. As there are a number of research findings indicating that PA behaviours follow on from childhood to adulthood [28], the enhancement of PA and a healthy lifestyle in children and adolescents is a task of public education institutions and physical education at different educational levels [18, 30]. PA guidelines are typically expressed in terms of frequency, duration, intensity parameters and sometimes the form of PA taken [17, 45]. Pedometers offer a chance to measure and communicate PA in terms of steps per day. Pedometers are inexpensive, easy to use, easily interpretable as indicators of PA levels and are more likely to be used in a public health context than other tools [41].

According to the WHO [45], it is recommended that children and adolescents aged 5–17 should participate in at least 60 minutes of moderate – to vigorous-intensity PA daily. Results of an analysis by Tudor-Locke et al. [40] showed that 60 minutes of moderate – to vigorous-intensity PA (MVPA) in children appears to be achieved, on average, within a total volume of 13000 to 15000 steps per day in boys and 11000 to 12000 steps per day in girls. For adolescents (both boys and girls), 10000 to 11700 steps may be associated with 60 minutes of MVPA. Tudor-Locke et al. [38] have suggested that when we take BMI levels into consideration, the optimal cut-off point separating normal weight and overweight or obese students was 12000 steps per day for girls. Furthermore, Colley, Janssen and Tremblay [6] propose that 12000 steps per day may be used as a target to determine whether children and youths aged 6–19 are meeting the current PA guidelines of 60 minutes of daily MVPA.

Tudor-Locke et al. [40] indicated that we can expect female children to average 10000 to 13000 steps per day and adolescents to steadily decrease steps per day to approximately 8000–9000 steps per day in 18-year-olds. Brusseau, Tudor-Locke and Kulinna [3] reported that only 27% percent of girls in primary school and 30% of overweight and obese children met the recommendation of 12000 steps per day. Craig et al. [7] found that 11.7% of female children and adolescents aged 5–19 years met the recommendation of 15000 steps per day.

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Because of the obesity epidemic [20], and also the fact that many adolescents are underweight [21], a better understanding of the PA patterns of children and adolescents is needed in order to conduct programmes aimed at improving health behaviours. It is well-documented that regular PA, with intensity levels adjusted to specific age categories, gives young people numerous health benefits (including muscular, aerobic, bone strength and optimal body mass benefits) [33, 35], whereas inactivity brings about a vast number of health-related problems, especially related to an increase in body mass and lowered aerobic fitness [4, 43], leading to civilization disease syndrome. Research on the relationships between PA and BMI have been carried out systematically and PA has been evaluated usually using questionnaires. However, the topic of step counts and their relationship with BMI need further exploration. One of the observations in previous pedometer-based studies has been that girls take significantly fewer steps than boys [13, 24]. Therefore, the aim of this study was to assess the step counts of female children and adolescents with different BMIs and to present the results in the light of step count recommendations.

Material and methods

Participants

The study included data from 175 girls, aged 12–18, from different educational levels: 45 participants from primary school (aged 12–13, body mass [kg] – 42.9 ± 9.3, body height [cm] – 150.6 ± 7.9, BMI [kg/m^2] – 18.9 ± 3.8); 69 participants from junior high school (aged 15–16, body mass [kg] – 55.6 ± 9.7, body height [cm] – 163.9 ± 5.7, BMI [kg/m^2] – 20.7 ± 3.6) and 61 participants from high school (aged 17–18, body mass [kg] – 58.0 ± 10.1, body height [cm] – 163.4 ± 6.2, BMI [kg/m^2] – 21.7 ± 3.6). Participants were recruited voluntarily from public schools.

The study protocol was approved by the Local Bioethics Committee of Karol Marcinkowski University of Medical Sciences in Poznan (decision no. 893/12). Written consent from all participants and consent from parents of minors was also obtained.

Step counts and BMI measurements

Students taking part in the study wore a pedometer for the duration of seven consecutive days, excluding time spent sleeping and swimming. Data from the pedometers were collected during physical education classes and the results were gathered by the physical education teacher. The number of steps taken was measured with a Yamax Digi-Walker SW 701 pedometer. This pedometer has been found to be a reliable instrument for measuring walking-type movements [36]. Body height and weight were self-determined and used to calculate body mass index (BMI), defined as weight in kilograms divided by the square of the height in meters (kg/m^2).

Statistical analysis

All analyses were performed using STATISTICA 10 (Stat. Soft, Inc.). Means, standard deviations and medians of numbers of steps and BMI were calculated. A Kruskal-Wallis analysis of ranks was used to compare numbers of steps at different levels of education and BMI, and the *p*-values for multiple comparisons were also calculated. Mann-Whitney tests were used to examine differences in BMI between the group that achieved recommended levels and the group that did not achieve the step count recommendation. The level of $\alpha = 0.05$ was considered significant.

Results

On average, the schoolgirls performed 9087 ± 3559 steps per day (participants from primary school: mean = 8286.0 ± 4510.6; from junior high school: mean = 9882.7 ± 3080.0; from high school: mean = 8778.7 ± 3121.9).

Significant differences, $H(2, N = 175) = 9.70, p < 0.01$, in the number of steps per day among groups of girls at different school levels were found (Fig. 1). The statistical significance was due to the differences between girls from primary school and junior high school ($p < 0.01$). Girls from junior high school (median = 9525.3) were more active than girls from primary school (median = 7894.1).

There were statistically significant differences in the BMI of girls from primary school, junior high school and high school, $H(2, N = 173) = 24.53$, $p < 0.001$ (Fig. 2). Significant differences were observed between girls from primary school and junior high school ($p < 0.01$), and primary school girls and high school girls ($p < 0.001$). Primary school girls (median = 17.9) had a lower BMI than girls from junior high school (median = 19.8) and girls from high school (median = 21.1).

The recommended level of 12000 steps per day was achieved by only 26 girls (14.9%). Over 85% of girls (n = 149) did not accomplish the recommended number of steps per day. Detailed results of achieving or not achieving recommended levels at each stage of education are shown in Table 1.

There were significant differences in BMI ($Z = –2.11$, $p < 0.05$) between the groups of girls which accomplished or did not accomplish the recommended level of 12000 steps per day (Fig. 3). Girls who reached the recommended number of steps per day had a lower BMI.

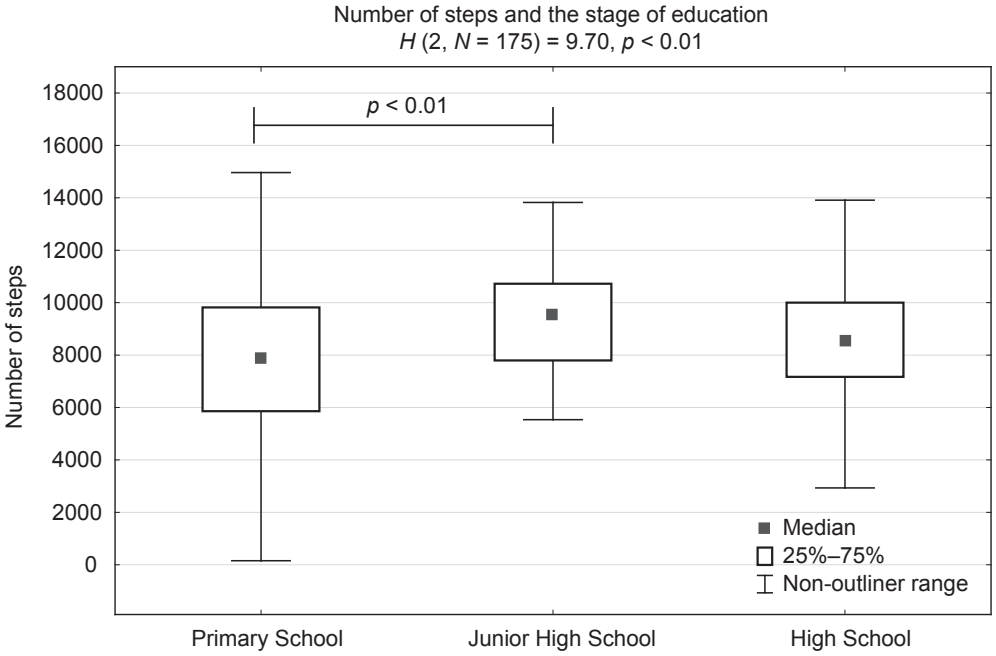

Fig. 1. Number of steps performed by girls during the day and the level of education

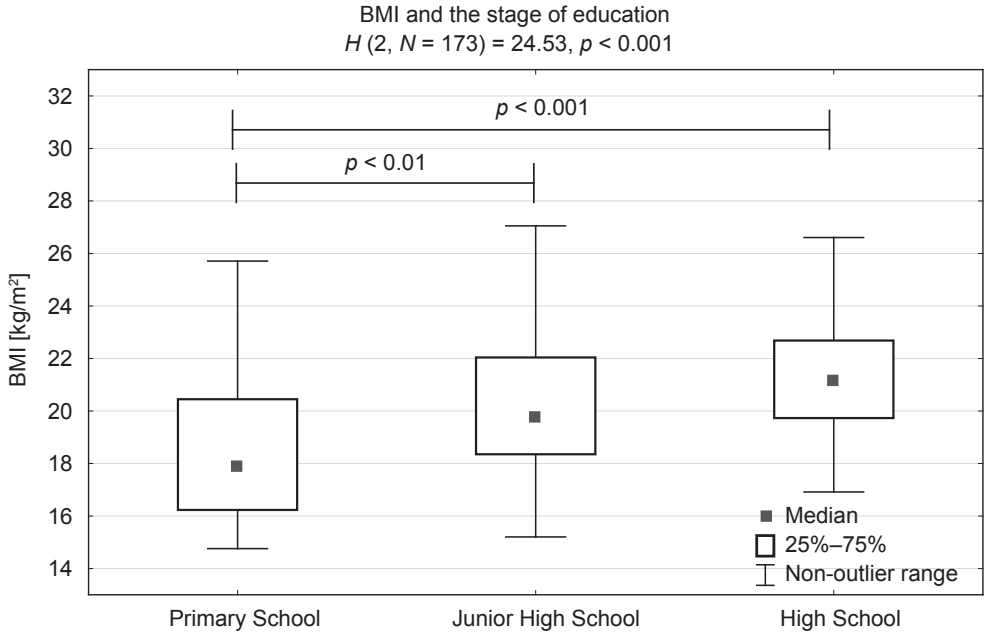

Fig. 2. BMI differences in girls from primary school, junior high school and high school

Table 1. Number of girls achieving or not achieving recommended levels at each stage of education

	N	12000 or more steps/day	%	Less than 12000 steps/day	%
Primary School	45	7	15.6	38	84.4
Junior High School	69	8	11.6	61	88.4
High School	61	11	18.0	50	82.0

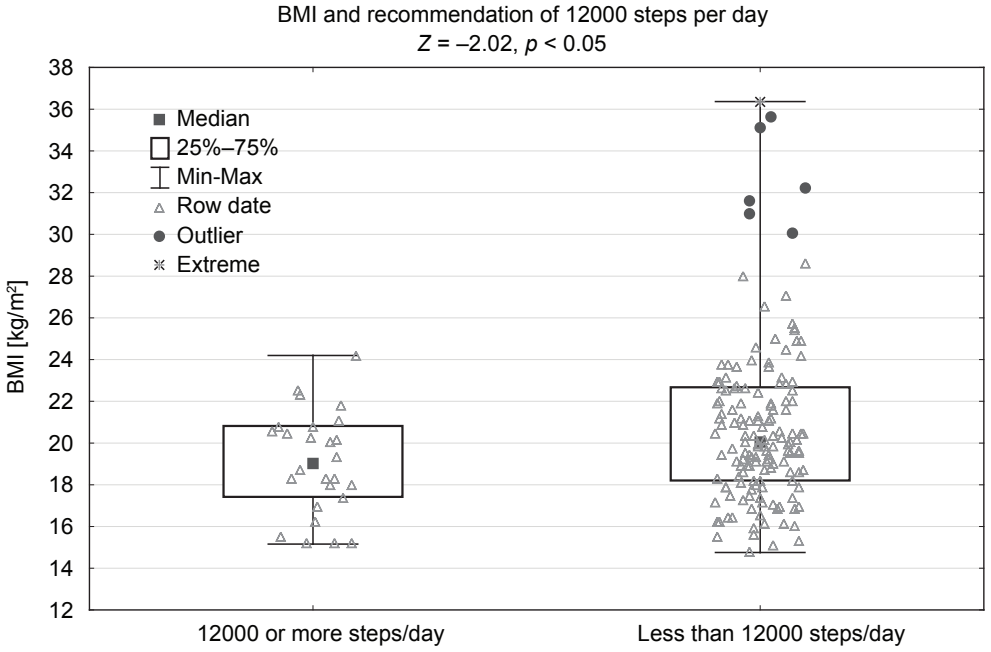

Fig. 3. BMI differences in girls which accomplished or did not accomplish the recommended level of 12000 steps per day

Discussion

This study investigated the step counts of female children and adolescents with different BMIs. The recommended level of 12000 steps per day was achieved by only 14.9% of participants. Girls who reached the recommended number of steps had a lower BMI and girls who did not take a sufficient number of steps were characterized by a higher BMI. This finding is in line with previous studies which confirm the generally accepted belief that as PA levels decrease, BMI increases [1, 9, 37, 42]. However, it is worth noting that only a few studies have examined this relationship using pedometers. Michalopoulou et al. [31] reported that among 532 children (269 girls) aged 9–14, those with a lower BMI (classified as normal weight) performed significantly more steps per day than their peers with a higher BMI (classified as over-weight and obese). Also Duncan, Duncan, and Schofield [14] have indicated that PA levels analysed using pedometers in 224 boys and 289 girls aged 8–14 were significantly greater among girls with a lower BMI. However, this issue still requires further study. It is possible that girls with a lower BMI are more physically active. There may also be an inverse relationship, however, and accomplishing the recommended step counts might lead to a reduction of BMI [29]. The above findings indicate that the relationship between BMI and step counts are the reverse of trends found in some studies. Chan, Ryan and Tudor-Locke [5] have noted that daily step counts not related to BMI. Also, Oh and Rana [32] have observed that pedometer-assessed physical activity did not correlate with BMI in 68 boys and 81 girls of middle and high school age. It should be noted that the diversity of results from different studies is associated with fact that BMI depends on many variables, for example nutrition, genetics, ethnicity and rate of sexual maturation [9, 27], which were not investigated in the present study.

In addition, this paper presents the step counts achieved by girls from primary school, junior high school and high school in relation to the recommended step count levels. The most physically active were girls from junior high school, and the least active were primary school girls. Significant differences were found between girls from primary school and junior high school. These results are partly consistent with findings obtained by other researchers [32]. Sallis [34] has reported that the greatest decline in PA is between the ages of 13 and 18 (between junior high school and high school). Different studies have demonstrated that younger children take more steps per day than their older colleagues [12, 31, 39]. However, in the current study, girls from primary school were the least active. The reasons for the low step counts in this age group are unclear. The results obtained in our studies may be related to different factors which have not been analysed in this paper. One of them might be that the level of PA in primary school children depends on parents' PA and lifestyle [8, 16]. In the case of younger children, another factor may be associated with access and to use of different types of transport. Often, parents who perceive the unsupervised use of public transport as risky do not allow

primary school children to walk to and from school, while junior high school and high school girls often use public transport or go on foot. These factors could influence the level of PA, as assessed by step count [12, 22]. A similar link has been mentioned by Faulkner et al. [19], who indicated that active school commuters tend to be more physically active than passive ones.

In the present study, the lowest BMI was recorded in girls from primary school. Significant differences were found between girls from primary school and junior high school, and primary school girls and high school girls. These data are consistent with other reports [23]. The recorded increase of BMI may be related to biological development and maturation processes, which is characterized by a marked growth in adipose tissue content in adolescent girls [10, 23, 26].

Several limitations and strengths should be noted regarding this study. Firstly, pedometers have been found to be a reliable instrument for measuring walking-type movements, which can be considered a strength. One of the limitations is self-reported height and weight. As has been observed in previous studies, an underestimation of weight and an overestimation of height may lead to a subsequent underestimation of BMI [2, 15]. Secondly, another limitation is that all data were collected during one week and that a relatively small sample of participants was recruited. Moreover, the pedometers used in the present study only measured step count, not the intensity of PA.

In conclusion, few female children and adolescents are meeting the daily step count recommendation. The obtained findings suggest that female children and adolescents who take the recommended daily number of steps (who are, therefore, physically active) have a lower BMI compared to those who do not take a sufficient number of steps. More research on this topic is needed to achieve substantial behavioural changes and develop effective interventions that stimulate children and adolescents to increase their PA.

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