

Research article

Step counts and body mass index among 9-14 years old Greek schoolchildren

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Abstract

The main purpose of this study was the identification of the current pedometer determined physical activity levels of a large sample of 9-14 years old Greek schoolchildren and the determination of the association between daily step counts and body mass index through the comparison of step counts among overweight, obese and normal-weight children. A total of 532 children (263 boys and 269 girls) were measured for height and weight. Their activity levels were analyzed using pedometers to measure mean steps for 7 consecutive days. Overweight and obese status was determined using the international reference standard (Cole et al., 2000). According to data analysis mean step counts ranged from 15371 to 10539 for boys and from 11536 to 7893 for girls. Steps per day were significantly more for boys compared to girls. Children with normal weight performed significantly more steps per day compared to their overweight and obese classmates. Daily step counts reported in this study for 9-14 year old schoolchildren were relatively low when compared to step counts from other European countries. Only 33.9% of the participants satisfied the body mass index referenced standards for recommended steps per day. Finally, the results of this study provide baseline information on youth pedometer determined physical activity and on youth body mass index levels. High prevalence of low daily step counts and BMI determined obesity was revealed prompting for further exploration of the relationship between objectively measured physical activity and adiposity in particular for children and adolescents that experience both health risk factors.

Key words: Childhood, obesity, pedometry.

Introduction

A major health threat for young people (aged 5-18) in the 21st century is physical inactivity in conjunction with the elevated prevalence of obesity (WHO 2004). Even though many countries exhibited low levels of physical activity for youth (Le Masurier et al., 2005) clear differences have been reported in levels of physical activity as recorded by pedometer among young people from individual countries and regions (Beets et al., 2010).

A cumulative record of steps taken over the course of the day is a suitable marker to track accumulation of daily physical activity in youth as has been the focus of respective guidelines in relation to youth - appropriate public health (McClain and Tudor-Locke, 2009). Such guidelines made available for recommended daily step counts are gender specific and range from 11,000 to 16,500 step day⁻¹ (Duncan, Schofield and Duncan, 2006; Tudor-Locke et al., 2004; Vincent and Pangrazi, 2002a) even though differences among countries indicate that a

single global steps/day recommendation of a given age may be unrealistic (Beets et al., 2010).

Recent studies by CFLRI (Matthews et al., 2008) and NHANES (Troiano, 2009) demonstrated that pedometers are an inexpensive method for objective monitoring to be performed at a population level. Furthermore researches have addressed several important issues related to pedometer use as youth physical activity surveillance tools in relation to their accuracy (Tudor-Locke et al., 2002), reactivity (Ozdoba et al., 2004) and number of monitoring days needed to determine habitual physical activity (Vincent and Pangrazi, 2002b) even though further scrutiny in this area of inquiry is needed (Tudor-Locke et al., 2009a).

Regarding age, Tudor-Locke et al. (2009b) reported that the habitual activity curve formed in their study for both sexes, indicated that the youngest age groups appeared to take more steps per day than those immediately older. The greatest decline in physical activity has been reported between the ages of 13-18 years (Sallis, 2000) or during the transition from elementary to high school years (Raustorp et al., 2004), since "high school students are on their way of becoming sedentary adults" (LeMasurier et al., 2005, pp.166). Contradicting results support the idea that physical activity remains stable throughout childhood (6-12 years) and a significant decrease is recorded in pre-adolescent years (13-14 years), (Trost et al., 2002; Vincent et al., 2003; Vincent and Pangrazi 2002b; Nyberg et al., 2009).

Consistent evidence of negative association exists between objectively measured physical activity and adiposity. Several longitudinal as well as cross-sectional studies using Body Mass Index (BMI) as a measure of adiposity and pedometers (steps/day) as a measure of habitual physical activity have supported the above negative relation (Cleland et al., 2008; Cuddihy et al., 2006; Elgar et al., 2005; Hands and Parker, 2008; Jago et al., 2006; Moore et al., 2003; Ziviani et al., 2008).

A recent study conducted in Greece using IOTF criteria based on BMI status, reported a dramatic increase (54%) in prevalence of obesity in the past decade among 8-9 year old children of both genders even though the obesity rates were leveling off during the years 2004-2007 (Tambalis et al., 2010). Although these cut points are not diagnostic criteria, elevated BMI among children most often indicates increased risk for future adverse health outcomes and/or development of disease, (USDHHS, 2010).

Previous studies on reported physical activity levels of children and adolescents in Greece reported that

boys were more active than girls and age affects negatively physical activity and participation in organized sport (Avgerinos et al., 2002; Bertaki et al., 2007).

The need for further exploration of the relationship between objectively measured physical activity (daily step counts) and adiposity exists. In addition to that, no similar study has been performed within Greek children proving pedometer determined physical activity data. Therefore, the main purpose of the present study was to determine pedometer determined physical activity data and to examine its relationship to body mass index of 9 to 14 year old Greek schoolchildren. Daily step counts and BMI levels were used to measure physical activity and adiposity, respectively. Comparisons were performed for age and gender. Finally, a secondary objective was to determine the percentage of the participants who satisfied the BMI-referenced standards for recommended steps per day in childhood according to cutoff points suggested by Tudor-Locke et al. (2004).

Methods

Participants

Data were collected during the 2009 school year. Participants in this study were recruited from 8 out of 19 schools operating in the school district of the Municipality of Komotini, in Northern Greece. The 8 schools that participated in this study were selected based on size, proximity and accessibility (4 of the 19 schools had less than 30 students and are located distances greater than 50km) and issues of cultural origin since 3 of the schools operating in this district are schools of the Muslim minority. Out of the 12 schools that satisfied the above criteria, only 8 schools were randomly selected to participate in the study and this selection was imposed by the number of available instrumentation (pedometers). Komotini is a municipality with both urban and rural areas and 3 of the schools selected were in the rural and 5 in the urban areas. Of the 1135 possible participants 782 volunteered to participate in the study and finally 532 children aged 9 to 14 (263 boys and 269 girls) completed all data collection procedures. Reasons for non participation were absence during the first day of study, illness and lack of parental permission. The parent or legal guardian of each child gave a written informed consent to their child's participation in the study. The Ethics Committee of the Dept of Physical Education of Sport Sciences, of the Democritus University of Thrace, Komotini Greece and the principals of the schools approved the study.

Instrumentation and procedures

Somatometric measures

Height and weight were assessed individually with children dressed in light clothing and without shoes. Height was measured to the nearest 1.0 cm using a portable stadiometer (SECA 242; Hamburg, Germany). Weight was measured to the nearest 0.1 kg using a high precision electronic scale (SECA 764; Hamburg, Germany) that was being calibrated before each use against a standard weight. Body Mass Index (BMI) was calculated as body mass in kilograms divided by height in squared meters

($\text{kg}\cdot\text{m}^{-2}$). The children then were classified as normal-weight, overweight and obese according to the international reference standards (Cole et al., 2000). These standards are based on average percentiles, determining BMI cutoff points of 25 or 30 at age 18 for overweight or obesity, respectively.

Pedometer determined physical activity measure

The Yamax model SW200 (Yamax Corporation Tokyo) pedometer, was used to monitor daily step counts for seven consecutive days (Strycker et al., 2007). Previous research has established pedometers as a valid measure of activity in children (Sirard and Pate, 2001), especially in large-scale studies such as the current one. Before its actual use, each pedometer was checked for defects and for accuracy by observing the recorded step count after walking 100 paces. Instrumental error did not exceed 3% in any of the pedometers (Tudor-Locke and Myers, 2001). The type of the pedometer used in this study records within 1% of all steps taken under controlled conditions (Bassett et al., 1996). Testing took place during October and November.

Children were instructed to wear the pedometer attached to their waistband during waking hours for seven consecutive days. They were also asked to continue their typical activities and to remove the pedometer only at bed time and bathing and to put it right back on (e.g. after dressing each morning). The pedometer was fastening to the waistband of the participants' pants or shorts. When no waistband was available a small elastic belt was worn with the pedometer attached to the belt. Children were also given written instructions on how to wear and to use the pedometer. Prior to participation in the study, all participants had the opportunity, during physical education class, to become familiar with the pedometer. During the study all pedometers were sealed to assure that they would not be accidentally reset. Each day, eight trained researchers were collecting the pedometers, recorded the number of steps revealed them and returned them to the participants (Tudor-Locke et al., 2002). Daily steps lower than 1000 or above 30.000 were unlikely to be valid and were regarded as outliers (Rowe et al., 2004). If a participant missed more than three days of step counts he/she was excluded for the study. Mean steps per day were computed for the whole week for each participant.

Statistical analysis

According to their (body weight and height) scores that were recorded during this study, participants were assigned for analysis purposes to one of the three groups: normal weight, overweight and obese, according to the international reference standards (Cole et al., 2000). Descriptive statistics were performed for all study variables. In order to address differences regarding the participants' steps per day, a 3 X 2 analysis of variance was performed with BMI (normal weight, overweight and obesity) and gender (male and female) being the independent variables. Bonferroni post hoc tests were performed when needed. Bivariate analysis for testing associations between variables was performed using Pearson moment correlation. The level of significance was set at .05.

Table 2. Numbers (n) and steps/day for boys and girls presented in age groups. Data are means (±SD).

Age (years)	n	Boys	Girls	Total		
		Daily step count	Daily step count	N	Daily step count	
9	42	15.371 (3.005)	45	10.090 (3.387)	87	12.203 (4.132)
10	45	14.069 (4.476)	44	11.536 (3.698)	89	12.758 (4.272)
11	46	13.009 (4.624)	46	11.015 (4.171)	92	11.901 (4.478)
12	43	13.634 (4.731)	45	10.129 (4.194)	88	12.262 (4.825)
13	40	12.694 (3.328)	44	9.754 (3.637)	84	11.855 (3.552)
14	47	10.539 (4.303)	45	7.893 (3.158)	92	8.939 (3.834)
Total	263	13.446 (4.549)	269	10.656 (3.986)	532	12.036 (4.492)

Results

Descriptive data for the physical characteristics of the participants are presented in Table 1.

Table 1. Participants characteristics (mean ± SD) by age and gender.

	Boys	Girls	Total
N	263	269	532
Age (years)	11.13 (1.30)	11.05 (1.39)	11.69 (1.31)
Height (m)	1.51 (.11)	1.50 (.10)	1.50 (0.2)
Weight (kg)	45.0 (11.8)	43.4 (11.0)	44.1 (11.4)
BMI	19.6 (3.4)	19.1 (3.4)	19.4 (3.4)

Age effect

Steps per day were calculated by gender and age to determine activity levels of children (Table 2). According to one-way ANOVA significant differences in steps/day were reported ($F_{(5,526)} = 5.276, p < 0.001, \eta^2 = 0.45$), only between the 14year old children and the other age groups used in this study, ($p < 0.001$). Bonferroni post hoc tests revealed that 14year old children were significantly less active when compared to the younger children that participated in this study (Table 2).

Body Mass Index scores

International BMI cutoff points for childhood overweight and obesity were applied to the sample (Cole et al., 2000). Overall 69.9% of participants were classified as “normal” weight, 23.9% were classified as “overweight” and 6.3% as obese. In particular, for boys and girls respectively, 69.1% and 70.4% had normal weight, 23% and 24.8% were overweight and 7.8% and 4.7% were obese. The number and percentage of children that satisfied the BMI-referenced standards for pedometer steps/day in preadolescent youth (Tudor-Locke et al., 2004) according to their BMI status are presented in Table 3 and only 52% of them satisfied the classification according to their steps per day readings and their BMI status.

According to two-way ANOVA no significant interaction was revealed between the factors BMI and gender ($F_{(5,526)} = 0.704, p = 0.495, \eta^2 = 0.30$). Both factors, gender ($F_{(1,526)} = 17.490, p < 0.001, \eta^2 = 0.56$) and BMI ($F_{(2,526)} = 15.536, p < 0.001, \eta^2 = 0.32$) had a significant main effect on steps/day. Bonferroni post hoc test re-

vealed that the boys exhibited significantly higher scores of steps per day than girls ($p < 0.001$) and children with normal weight performed significantly more steps/day than children classified as overweight ($p < 0.001$) and obese ($p < 0.001$). Additionally no significant differences in the number of steps/day performed by children classified as overweight and obese ($p = 0.272$) (Table 4 and Figure 1).

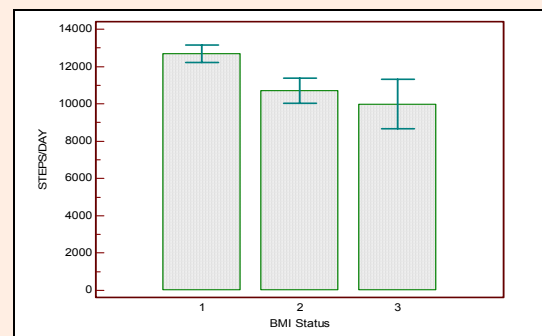


Figure 1. Steps/day of the participants according to BMI status (1= normal weight, 2 overweight and 3 obese) according to the international reference standards (Cole et al., 2000).

Correlation between physical activity and body mass index

The correlations between steps per day and BMI were calculated for each age group for boys and girls. Significant correlations were reported for both boys and girls in different age groups. The results are presented in Table 5.

Table 5. Correlations (r) between steps/day and body mass index for boys and girls presented in gender and age groups.

Age (y)	Boys	Girls
9	-.047	.033
10	-.398 *	-.154
11	-.455 ***	-.253 *
12	-.406 ***	-.511 ***
13	-.399 *	-.844
14	-.598 **	-.146
Total	-.395 ***	-.277 ***
N 543	-.295 ***	

* $p < 0.05$ ** $p < 0.001$

Table 3. Classification (n, %) of children according to BMI status and to steps/day for all the participants in the study.

	BMI Status			Total
	Normal Weight	Overweight	Obese	
Boys >15.000 daily steps	149 (39.3%)	30 (23.1%)	5 (14.7%)	184 (33.9%)
Girls > 12.000 daily steps				
Boys <15.000 daily steps	230 (60.7%)	100 (76.9%)	29 (85.3%)	359 (66.1%)
Girls < 12.000 daily steps				
Total	379	130	34	543

Table 4. Numbers (n) and daily steps counts according to prevalence of overweight and obesity according to the international BMI cut-off points for boys and girls.

BMI status	n	Boys		Girls		Total	
		Daily step count		Daily step count		N	Daily step count
Normal Weight	181	14.266 (4.553)		11.167 (4.117)		370	12.684 (4.599)
Overweight	61	12.001 (3.877)		9.526 (3.484)		128	10.705 (3.867)
Obese	21	10.571 (4.274)		9.048 (2.902)		34	9.988 (3.834)
Total	263	13.446 (4.549)		10.656 (3.986)		532	12.035 (4.492)

Discussion

Participants' pedometer-determined-physical activity levels

This study examined current activity levels of children and pre-adolescents (9-14 years of age) using pedometry, a low cost, user friendly, reliable and valid way to assess suggest that the participants in this study were at the low physical activity in youth (Tudor-Locke et al., 2002). As for the occurrence of reactivity (when the testing process influences behavior) that has been discussed in the literature, the procedure followed in this study satisfied the measurement schedule for obtaining reliable pedometer data (6 consecutive days assuming that this has been preceded by a familiarization day and both weekend days and week days being included) (Vincent and Pangrazy, 2002a; 2002b; Rowe et al., 2004), since children in this study wore the pedometer for 7 consecutive days.

According to the findings of this study the mean steps/day taken by both boys and girls in Greece (13.446 and 10.656 respectively), were similar to the ones reported by a previous study performed in Greek 9-11 year-olds where boys and girls accumulated 12.362 and 10.140 steps respectively (Bertaki et al., 2009). These figures end of pedometer-determined-physical-activity levels when compared to data provided by other European countries: Sweden, UK and Cyprus (Loucaides et al., 2004; Raustorp et al., 2004; Rowlands et al., 1999). According to Beets et al. (2010) physical activity levels in the above countries are notably high and young people are on average healthier. On the other hand, figures closer to the ones of the present study have been recorded for children in US (Le Masurier et al., 2005; Vincent et al., 2003). The low values may be due to the fact that children in Greece have limited opportunities to be physically active within the school environment and participation in after school sports programs is limited to only 1/3 of them (Avgerinos et al., 2002). Additionally, it should be mentioned that participants in the present study reside in one of the poorest and less privileged European Regions (Thrace), where activity opportunities may be limited. Interaction between socioeconomic status and physical activity may affect children's pedometer determined physical activity level (Sallis et al., 2000; Stamatakis et al., 2005; Ziviani et al., 2008).

In the present study, daily step-counts tended to be leveled for ages 9-12 years, a finding which is accordance with those of previous studies supporting a consistent accumulation of steps throughout the ages 6 -12, (Vincent et al., 2003; Vincent and Pangrazi 2002a; Le Masurier et al., 2005). Different findings have been also reported for decreasing activity levels before adolescence (Goran et al., 1998; Hovell et al., 1999; Nyberg et al., 2009).

The significant drop in steps/day that was apparent in this study only for children aged 13 -14 years, is in accordance with other the results of studies examining physical activity levels of preadolescent children (LeMasurier et al., 2005; Raustorp et al., 2004). As previously reported when children in Greece approach adolescence drastically they reduce their physical activity since opportunities to be physically active diminish (less physical education classes, and decreased discretionary time; Avgerinos, et al., 2002).

Furthermore, regarding sex differences, the results revealed that boys were more active than girls in all age groups a finding reported in many studies on adolescents and children (Duncan et al., 2006; LeMasurier et al., 2005; Raustorp et al., 2004; Tudor-Locke et al., 2009b; Vincent et al., 2003; Vincent and Pangrazi, 2002a). It has been reported that 12- 19 year old girls in Greece expressed lower interest than boys for physical activity and sports participation and higher interest for social interaction (Avgerinos et al., 2002). The current finding may reflect the above trend.

BMI and pedometry

A general finding of the present study was that, according to the IOTF criteria based on BMI status, 23% of the boys who participated in this study were overweight and 7.8% were obese, while in girls the respective rates were 24.8% and 4.7%. These findings are very alarming of high obesity rates in Greek children since other recent studies conducted in Greece reported similar overweight and obesity prevalence rates for both sexes, (Panagiotakos et al., 2008; Papandreou et al., 2008).

Overweight and obesity prevalence in similar studies in other countries were lower for children in New Zealand (26.5%; Duncan et al., 2006), in South Eastern Sweden (19%; Raustorp et al., 2004), in Australia (14.4%) and in Sweden (6.8%). Opposite results have been reported in U.S. where over 33% of the children aged 6-12 years were classified as overweight/obese (Vincent et al., 2003).

As physical activity is an important factor in weight control (Welk and Blair, 2000), a larger and more consistent body of evidence of significant negative associations between habitual physical activity and adiposity, has been reported in cross-sectional studies using pedometry (Jimenez-Pavon et al., 2009). In the current study, nine out of the fifteen correlations that were calculated between BMI and steps/day counts, were significant but rather low to moderate. On the other hand, no significant correlations have emerged regarding 9-year boys' group and 9, 10, 13 and 14-year girls' groups. This may be related to the fact that physical activity is only one of the modifiable risk factors for obesity (along with sedentary

behavior and diet; USDHHS, 2010). In addition to that, BMI as a measure of obesity in childhood has exhibited several limitations (Prentice and Jebb, 2001). BMI seems to be affected by the natural increases in weight and height that occur during growth and this may further complicate its relationship with pedometer-determined-physical-activity. The effect of maturity status and adolescent growth spurt on body composition may be an explanation of the limited correlations between habitual physical activity and BMI regarding girls. More direct measures of body fatness (% of body fat and waist circumference) may strengthen the possibility of defining the relationship between adiposity and objectively determined physical activity. For all the other boys' age groups (10-14 year-olds) correlations were significant, a finding which is accordance with a previous studies (Raustorp, et al., 2006).

Given the limitation of BMI as a measure of obesity in youth (Prentice and Jebb, 2001), normal-weighted participants of the current study performed significantly more steps/day compared to their overweight and the obese mates. These findings are in accordance with those of previous studies (Bar-Or, 2000; Duncan et al., 2006). The above drop in steps/day for overweight and obese children has been also reported by Jago et al., (2006) in a study of 11-15 year old Boy-Scouts as well as by Al-Hazzaa (2007) in a study of 8-12 year old Saudi-Arabi school boys.

Practical implications

Insufficient vigorous physical activity was shown to be a risk factor for higher BMI, and failing to meet the 60 minutes/day of moderate to vigorous physical activity guidelines (NASPE, 2004) was associated with overweight status for adolescent boys and girls from the United States (Patrick et al., 2004). The only participants in the current study who satisfied NASPE guidelines were normal-weighted boys and girls whereas all the other subgroups (overweight and obese) performed significantly less steps/day. Tzetzis et al. (2005) reported that overweight and obese 12-13 year old Greek children participated less in both moderate and vigorous physical activity when compared to children with normal weight. Furthermore, according to the results of a recent study performed in Greece, obese adolescent girls performed 3.000+895 steps/day, a daily step count that is surprising low (Agorastou and Avgerinos, 2009).

Further attention should be given to the fact that only 33.9% of the participants (184 children), satisfied the Tudor-Locke et al., (2004) criterion-referenced standards (12.000 steps/day for girls and 15.000 steps/day for boys) based on BMI categories in children. Additionally, 230 children who had normal weight (42.4% of the total sample), did not satisfy the step/day standard and 81% of the 184 children that satisfied the step/day standard had normal weight, 16,3% were overweight and 2,7% were obese. Even though steps/day values in this study were close to the ones reported for U.S. youth, the aforementioned cut off points failed to distinguish between youth classified as healthy- or unhealthy-weighted according to international BMI age - and-sex-specific categories. Similar results have been reported by Beets et al. (2008),

where these steps/day cut off points were unable to distinguish between U.S. youth classified as healthy- or unhealthy-weighted and thus they should be used with caution.

Several limitations should be noted regarding this study. First, the findings can be generalized strictly to the specific sample since convenience sampling concerning city and school selection was used in this study. Second, this was a cross sectional study and therefore the temporal relationship between pedometer determined physical activity and obesity cannot be certain and any assumption of causality between inactivity and obesity indices is precluded. It remains unclear whether the obesity of the participants in this study was due to reduced levels of pedometer determined physical activity or the low step/day readings were the result of being obese. Third, although pedometry provides a low cost and objective measure of habitual physical activity (steps/day), the choices for interpretation of data are rather limited since we were unable to assess intensity, frequency and duration of activity or to estimate energy expenditure. Fourth, even though preliminary evidence suggests that anthropometric differences in leg length should be accounted for since they provide a closer approximation of the individualized steps·min⁻¹, no adjustments were made for respective differences in participants leg length. Finally, BMI is a limited indicator of childhood obesity since it is only a surrogate and not a direct measure of body fatness.

Conclusion

In conclusion the results of this study provide baseline information on young's people pedometer determined physical activity and BMI levels according to international cut of points. These findings are alarming due to very low pedometer determined physical activity levels of children's as proposed in the literature, although the applicability of the BMI references pedometer step-count recommendations to children and adolescents in Greece needs to be further examined. Further understanding of how low activity levels and body composition of children relate to a healthy life style will allow us to define the modifiable risk factors for obesity in order to mitigate the emerging epidemic.

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Key points

- The mean steps/day taken by both boys and girls in Greece 9-14 years old were 13.446 and 10.656 respectively.
- Daily step counts tended to be leveled for ages 9-12 years and a significant drop in steps/day was apparent for children aged 13 -14 years.
- According to the IOTF criteria, 23% of the boys that participated in this study were overweight and 7.8% were obese, while in girls the respective rates were 24.8% and 4.7%.
- Children with normal weight performed significantly more steps/day than the overweight and the obese children.

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