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Pedometer-determined Physical Activity among Obese and Non-obese 8- to 12-year-old Saudi Schoolboys

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Abstract Physical activity levels were measured in obese and non-obese 8- to 12- year-old schoolboys (n=296). Anthropometric measures included weight, height, body mass index (BMI), triceps and subscapular skinfolds, predicted fat percentage, fat mass (FM), fat-free mass (FFM), FM index (FMI), and FFM index (FFMI). Physical activity was assessed using an electronic pedometer for three continuous weekdays. Boys were divided into active and inactive groups based on daily accumulation of pedometer counts above or below 13,000 steps. Obesity was defined as body fat content that equals or exceeds 25% of body weight. The international age- and gender-specific child BMI cut-off points were also used to define overweight and obesity. Estimated fat content for the whole sample averaged 23.3±9.7%. More than 37% of the boys were classified as obese. The mean step counts were about 13,489±5,791 steps per day (range: 335–29,169 steps). Over 71% of the boys accumulated 10,000 steps or more per day. Based on BMI standards, mean step counts for the obese group (10,602±4,800 steps/day) were significantly ($p=0.004$) lower than in the normal group (14,271±5,576 steps/day). Based on fat percentage, obese boys also accumulated significantly ($p=0.009$) lower numbers of steps per day (12,682±5,236) than did non-obese boys (14,915±5,643). Further, there were significant differences ($p<0.05$) between active and inactive boys in weight, BMI, triceps and subscapular skinfolds, fat percentage, FMI, and flexibility. It is concluded that the prevalence of obesity and inactivity among Saudi boys aged 8–12 years was high. Active boys exhibited significantly lower body fat percentage and BMI than inactive peers. Obese boys, on the other hand, were significantly less active than non-obese boys. Increased prevalence of obesity and physical inactivity among Saudi children is a major public health concern. *J Physiol Anthropol 26(4): 459–465, 2007*
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Introduction

During the past two decades, dramatic increases in childhood overweight and obesity have been documented worldwide (Hedley et al., 2004; Janssen et al., 2005; WHO, 2000). Such an increase in the prevalence of obesity in young people is a great clinical and public health concern (Speiser et al., 2005; WHO, 2000). Obesity in childhood and adolescence has been associated with risks of hypertension, adverse lipid profile, type 2 diabetes, early atherosclerotic lesions and negative psychosocial consequences (Must and Straus, 1999; Reilly et al., 2003; Speiser et al., 2005; WHO, 2000). Another major concern about childhood obesity is that it somewhat tracks to adulthood (Guo et al., 2002).

The aetiology of obesity involves a complex interaction of numerous factors. Nevertheless, maintenance of normal body weight is a function of balancing energy intake and expenditure. Recently, many developing countries have witnessed rapid economic developments and enormous changes in dietary intake and habitual physical activity. Consequently, these lifestyle-related changes contributed significantly to the increased prevalence of obesity (WHO, 2000). In Saudi Arabia, for example, the prevalence of overweight and obesity among children and adolescents is rising (Abalkhail, 2002; Al-Hazzaa, 2007). At the same time, the proportion of inactive children and youth is considerably high. Nearly 60% of Saudi children and over 70% of youth do not engage in physical activity of sufficient duration and frequency (Al-Hazzaa, 2002, 2004a). Moreover, increasing time is spent on television viewing, video games, and computer use, which is contributing immensely to the inactivity epidemic among Saudi children and youth.

The benefits of physical activity for the health and well-being of human beings are well recognized (US Department of Health and Human Services, 1996; WHO, 2004). In children, such benefits include weight control, lower blood pressure, and improved fitness level and psychological well-being (US Department of Health and Human Services, 1996; Williams et al., 2002). Despite the benefits of active living, there is growing concern about the reduced levels of physical activity among children and youth (WHO, 2004). Reduced physical activity is contributing to the recent rise in childhood obesity (US Department of Health and Human Services, 1996). Physical activity levels were also reported to be lower in overweight compared to normal weight youth (Janssen et al., 2005). Understanding the relationship between obesity and physical activity levels in children is of great importance. Furthermore, establishing a consistent trend in the association between physical activity levels and childhood obesity in countries with differing cultures would strengthen the evidence linking obesity with reduced physical activity. Therefore, the objective of the present study was to examine the levels of physical activity among obese and nonobese 8- to 12- year-old Saudi school boys using pedometry as a measure of physical activity.

Methods

Participants included schoolboys between the ages of 8 and 12 years, who were selected from a nearby public school in the city of Riyadh. The selection of the school was considered a purposeful and not a random selection. Within the school, however, two classes were then randomly selected from grades 4, 5, and 6. The total sample was 296 boys. The study was approved by the Directorate of Research in the ministry of Education. All participants provided written consent signed by their parents. The study was conducted during the Spring of 2005. Body weight was measured without shoes and with minimal clothing to the nearest 0.1 kg using a Seca digital scale (model 770, Seca, Germany). Standing height was measured barefooted to the nearest 0.1 cm using a calibrated measuring rod (Seca Road Rod). In addition, triceps and subscapular skinfolds thicknesses were measured on the right side of the body using a Harpenden skinfolds caliper. Body fat percent was then calculated by a prediction equation specific for children and youth (Slaughter et al., 1988). Obesity was defined as body fat content that equals or exceeds 25% of total body weight (Lohman, 1992). In addition to body fat percentage, fat mass (FM), and fat-free mass (FFM), we calculated the FM index ($FMI=FM/height^2$) and FFM index ($FFMI=FFM/height^2$) normalized for body stature (VanItallie et al., 1990). Thus, FMI and FFMI are both discrete and adjusted for body size. Moreover, the international age- and gender-specific child body mass index (BMI) cut-off points were used to define overweight and obesity for each boy (Cole et al., 2000). Flexibility was also assessed using a sit and reach test.

Habitual physical activity was measured using an electronic pedometer (Yamax Digi-walker SW 701, Japan) for three continuous weekdays. Three days of measurements were shown to provide a reliable estimate of daily step counts, with an intraclass correlation coefficient of 0.80 (Tudor-Locke et al., 2005). Pedometers are simple and inexpensive body-worn motion sensors that are increasingly used for objective assessment of physical activity behaviors. The type of pedometer used in the present study was recently found to be valid for measuring steps (Courter et al., 2003). The instrument does not interfere with the child's normal daily activity. The pedometer was attached securely to the right hip of the child at the beginning of the school day. Participants were asked to maintain their normal activity patterns during the study period. Families were instructed to make sure that the pedometer stayed in place at all times except during sleeping and bathing. Boys who accumulated 13,000 steps or more per day were considered active. Previous research indicated that boys who accumulated 13,000 steps per day engaged in 60 minutes or more of moderate physical activity (Rowlands and Eston, 2005).

Data entry and statistical analysis were performed using the Statistical Package for the Social Science (SPSS) program, version 10 (Chicago, IL). Results are expressed as means and standard deviations or percentages. Boys were all divided into three equal age groups, and differences in anthropometric measurements and step counts were tested across age groups using one-way ANOVA, with Scheffe's post hoc test. In addition, two-factor analysis of variance was used to test differences in step counts, while obesity levels (obese versus nonobese) and activity levels (active versus inactive) were used as fixed factors. Since the interaction was found to be not significant ($p=0.568$), independent t-tests were used to test differences in anthropometric measurements and step counts between each of the obesity and activity levels. Pearson's correlation was used to determine the relationships between step counts, fat percentage, BMI, FMI, and FFMI. The significance level was set at 0.05.

Results

The descriptive characteristics including anthropometric, activity and flexibility measures for the participants are shown in Table 1. There was a wide variability in body weight. More than 37% of the boys had fat content exceeding 25% of body weight. The step counts also exhibited large variability, ranging from as low as 335 steps to as high as 29,169 steps. Over 71% of the boys accumulated 10,000 steps or more per day. However, there was a smaller proportion (38.7%) of boys who accumulated 15,000 steps or more per day.

The prevalence of overweight and obesity based on the international cut-off point for BMI averaged 20.3% and 12.4%, respectively. Figure 1 displays pedometer counts in normal ($BMI=16.7\pm1.9$), overweight ($BMI=22.0\pm1.7$), and obese ($BMI=27.3\pm3.0$) boys. The data clearly show a dose-response relationship between levels of activity based on step counts and the three categories of BMI values. However, only mean step counts for the obese group (10,602±4,800 steps per day) were significantly ($p=0.004$) lower than in the normal group (14,271±5,576 steps per day).

Table 2 presents the anthropometric measures, flexibility, and pedometer counts for the boys across three age groups. Anthropometric and body composition data increased significantly ($p<0.05$) from the younger to the older boys. Subscapular to triceps ratio, which represents trunk-to-limb skinfolds thickness, also increased significantly ($p=0.029$) from 73.6% in the younger boys to 86.6% in the older boys. However, flexibility and pedometer counts did not show any significant difference across age groups.

Table 1 Descriptive characteristics of the sample (n=296)

Variable	Mean	Standard Deviation	Range
Age (years)	10.3	1.3	8.1–12.6
Body weight (kg)	37.8	12.4	17.5–90.7
Body height (cm)	139.3	9.8	115.0–164.5
Body mass index (kg/m^2)	19.1	4.2	11.1–33.6
Triceps skinfold (mm)	15.0	6.9	3.2–40.2
Subscapular skinfold (mm)	12.2	9.2	3.4–51.7
Sum of skinfolds (mm)	27.0	15.3	8.4–79.0
Subscapular/triceps ratio (%)	77.8	30.5	40.0–281.3
Fat percent (%)	23.3	9.7	7.9–44.0
Fat mass (kg)	9.4	6.6	2.1–39.0
Fat-free mass (kg)	27.6	5.1	13.6–51.7
Fat mass index (kg/m^2)	4.7	2.9	1.0–14.4
Fat-free mass index (kg/m^2)	14.1	1.6	7.7–21.7
Flexibility (cm)	26.7	5.4	14.0–39.0
Step counts per day	13489	5791	335–29169

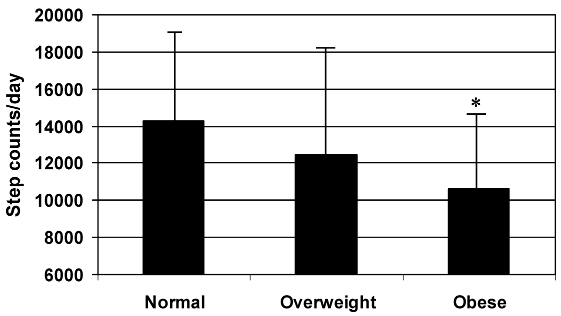

Fig. 1 Means and standard deviations of pedometer counts in normal (BMI=16.7±1.9), overweight (BMI=22.0±1.7), and obese (BMI=27.3±3.0) boys. * means significantly different from normal ($p=0.004$).

Comparison of active (=13,000 steps per day) and inactive (<13,000 steps per day) in anthropometric and flexibility measures is displayed in Table 3. Almost 53% of the boys were considered active and the remaining percentage was inactive. In addition, there were significant differences ($p<0.05$) between active and inactive boys in body weight, BMI, triceps and subscapular skinfolds, fat percentage, FMI, and flexibility. Inactive boys were fatter by more the 17% compared to active peers (fat%=25.3% versus 21.6%). However, there were no significant differences between the two groups in FFM or FFMI.

Comparison of obese (fat%=25% of body weight) and non-obese (fat%<25% of body weight) in the anthropometric measures, flexibility, and pedometer counts are shown in Table 4. About 63% of the boys were considered non-obese. Obese boys were slightly older than non-obese ($p=0.008$). However, this small age difference had no affect on the difference in levels of physical activity between the two groups. Obese boys accumulated significantly ($p=0.009$) lower numbers of step counts per day than did non-obese boys. Obese boys, however, were not less flexible than the non-obese boys. Furthermore, step counts per day showed significant negative relationships with fat percentage (r=−0.207; $p=0.006$), with BMI (r=−0.198; $p=0.007$), and with FMI (r=−0.214; $p=0.004$), but not with FFMI (r=−0.089; $p=0.231$).

Discussion

The findings of the present study indicate a high prevalence of obesity (37.2%) and physical inactivity (47.1%) among Saudi boys. Fat percentage also increased steadily from younger to older boys. This high prevalence of obesity and inactivity confirmed the earlier findings reported by many

Table 2 Descriptive characteristics of the sample classified by age group (means and standard deviations)

Variable	Age (years)			*p* Value*
	8.8±0.37	10.1±0.35	11.7±0.33	
Number of participants	97	89	110	
Body weight (kg)	29.4±6.7	38.5±11.0	44.8±12.9	0.000
Body height (cm)	130.0±5.7	140.4±7.6	146.8±7.2	0.000
Body mass index (kg/m^2)	17.3±3.0	19.3±4.1	20.6±4.7	0.000
Sum of skinfolds (mm)	21.5±11.7	27.9±14.7	30.9±17.6	0.003
Subscapular/triceps ratio (%)	73.6±22.0	74.3±29.2	86.6±37.2	0.029
Fat percent (%)	19.5±8.5	24.1±8.7	25.6±10.9	0.002
Fat mass (kg)	6.2±4.2	9.7±6.1	12.1±7.9	0.000
Fat-free mass (kg)	23.3±3.1	28.1±4.5	30.9±4.7	0.000
Fat mass index (kg/m^2)	3.6±2.3	4.8±2.7	5.5±3.4	0.001
Fat-free mass index (kg/m^2)	13.7±1.4	14.2±1.6	14.4±1.6	0.040
Flexibility (cm)	27.9±4.7	26.1±5.3	26.4±5.9	0.162
Step counts per day	13250±6142	14664±5558	12801±5462	0.077

* Levels of significance for the age differences based on one-way ANOVA tests.

Table 3 Anthropometric measurements for active (=13,000 steps per day) and inactive boys (<13,000 steps per day). Data are mean±standard deviation.

Variable	Active Boys	Inactive Boys	*p* value
Percentage of the total sample	52.9	47.1	
Age (years)	10.2±1.2	10.2±1.3	0.947
Body weight (kg)	35.3±9.9	39.8±14.0	0.002
Body height (cm)	138.5±8.9	139.5±10.3	0.371
Body mass index (kg/m^2)	18.1±3.6	20.0±4.7	0.000
Triceps skinfolds (mm)	13.8±6.1	16.6±7.6	0.006
Subscapular skinfolds (mm)	10.6±7.9	14.0±10.3	0.012
Sum of skinfolds (mm)	24.4±13.5	30.2±16.7	0.009
Subscapular/triceps ratio (%)	72.9±24.0	80.7±30.1	0.049
Fat percent (%)	21.6±9.2	25.3±9.8	0.010
Fat mass (kg)	8.3±5.8	10.7±7.3	0.015
Fat-free mass (kg)	26.9±4.5	27.9±5.6	0.160
Fat mass index (kg/m^2)	4.2±2.6	5.3±3.2	0.010
Fat-free mass index (kg/m^2)	14.0±1.5	14.2±1.6	0.244
Flexibility (cm)	27.7±5.1	25.9±5.4	0.019
Step counts per day	17838±3860	8646±3113	0.000

Table 4 Anthropometric measurements and activity levels of obese (fat percent <25% of body weight) and non-obese (fat percent <25% of body weight) boys. Data are mean±standard deviation.

Variable	Obese Boys	Non-obese Boys	*p* value
Percentage of the total sample	37.2	62.8	
Age (years)	10.4±1.1	10.0±1.1	0.008
Body weight (kg)	46.1±11.0	31.6±5.8	0.000
Body height (cm)	143.5±8.6	136.9±8.2	0.000
Body mass index (kg/m^2)	22.2±3.9	16.7±1.9	0.000
Sum of skinfolds (mm)	43.0±13.4	17.5±4.7	0.000
Subscapular/triceps ratio (%)	97.6±30.8	66.1±23.6	0.000
Fat percent (%)	34.1±5.7	16.9±4.4	0.000
Fat mass (kg)	16.1±6.2	5.5±2.1	0.000
Fat-free mass (kg)	29.9±5.4	26.2±4.4	0.000
Fat mass index (kg/m^2)	7.7±2.5	2.9±0.94	0.000
Fat-free mass index (kg/m^2)	14.5±1.8	13.9±1.4	0.011
Flexibility (cm)	26.8±5.7	26.7±5.1	0.983
Step counts per day*	12682±5236	14915±5643	0.009

* When ANCOVA was used while age was a covariate, age had no effect on step counts between obese and lean boys ($F=0.000$; $p=0.996$).

previous local studies (Al-Hazzaa, 2002, 2004; El-Hazmi and Warsy, 2002). Furthermore, the combined prevalence of overweight and obesity, based on the international age- and sex-specific child BMI cut-off points (Cole et al., 2000), for boys in the present study was 32.7%. This prevalence rate is higher than what was reported in an earlier study involving boys with a comparable age group from the central region of Saudi Arabia (El-Hazmi and Warsy, 2002). Overweight and obesity prevalence among children was also found in many developed and developing countries (Hedley et al., 2004; Janssen et al., 2005; WHO, 2000). Nowadays, obesity and physical inactivity in children represent an important public health concern (US Department of Health and Human Services, 1996).

There is ample support indicating that the pedometer is a valid instrument for assessing physical activity in research and practice. The median correlation between pedometers and accelerometers was found to be strong ($r=0.86$) (Tudor-Locke et al., 2002). In the present study, the average (±SD) step counts of 13,489 (±5,791) accumulated daily by the boys appears similar to the pedometer counts (13,864–15,023) previously reported for Australian boys 6–12 years (Vincent et al., 2003). However, compared to the boys in the present study, lower step counts (11,589±3,270) were reported for American boys of similar ages (LeMasurier and Corbin, 2006), but higher pedometer counts (15,673–18,346) were found in 6-12-year-old Swedish boys (Vincent et al., 2003), in 8-10-year-old British boys (16,035±5,998) as reported by Rowlands et al. (1999) and in New Zealand primary schoolboys (15,606±4,601) as reported by Cox et al. (2006).

The National Association for Sport and Physical Education of the United States has recently released physical activity guidelines for children ages 5–12 years (National Association for Sport and Physical Education, 2004). The guidelines state that children should accumulate at least 60 minutes, and up to several hours, of moderate to vigorous physical activity on all, or most days of the week. In 8-10-year-old British boys, Rowlands and Eston (2005) found that boys who accumulated 13,000 steps per day engaged in 60 minutes or more of moderate-intensity activity. Based on pedometer counts, more than 47% of the boys in the present study did not accumulate 13000 steps per day. Using accelerometer counts, the European Youth Heart Study indicated that the great majority (97.4%) of boys at age 9 years achieved current health-related physical activity recommendations (Riddoch et al., 2004). However, a Brazilian study using questionnaires found that 58% of adolescents aged 10–12 years were sedentary, based on 300 minutes of physical activity per week (Hallal et al., 2006).

The increased prevalence of obesity and physical inactivity among Saudi children reflects major changes in lifestyle-related factors observed in recent decades (Al-Hazzaa, 2004ab). High-energy food snacks are becoming readily available to the majority of Saudi children. Habitual active life among children and youth are largely diminished. Nowadays, children tend to walk or bicycle less and increasingly rely on cars for transportation (Al-Hazzaa, 2006). In addition, the use of sedentary entertainments, including television viewing, video games, and computers has dramatically increased. Opportunities for physical activity inside and outside schools may be what children really need in order to increase their levels of activity. The importance of physical education classes and community recreation centers in increasing physical activity among American adolescents was previously shown (Gordon-Larsen et al., 2000). Studies that used school-based physical activity intervention indicated significant improvements in activity levels as a result of such intervention (Stone et al., 1998). Walking to and from school can also boost the child's energy expenditure and contribute to energy balance. Reducing time spent watching TV is another strategy that can offer opportunities for children to be less sedentary. Recent research suggests that efforts to decrease time spent in sedentary activities resulted in weight loss among obese children in the United States (Epstein et al., 1995).

Our results showed that active boys exhibited significantly lower body fat percentage than inactive peers. Moreover, obese boys in the present study were significantly less active than nonobese boys. Elsewhere, insufficient vigorous physical activity was shown to be a risk factor for higher BMI, and that failing to meet the 60 minutes/day of moderate to vigorous physical activity guidelines was associated with overweight status for adolescent boys and girls from the United States (Patrick et al., 2004). In an international comparison survey involving youth 10–16 years from 34 countries, it was demonstrated that physical activity levels were lower and television viewing times were higher in overweight compared to normal weight youth. The study concluded that increasing physical activity participation and decreasing television viewing should be the focus of strategies aimed at preventing and treating overweight and obesity in youth (Janssen et al., 2005). Moreover, a multicenters European study conducted on 9- to 10-year-old children observed a significant difference in the sum of five skinfolds thickness between children who accumulated more than two hours of moderate and vigorous physical activity per day and those who accumulated less than one hour per day (Ekelund et al., 2004). In another study, obese children were shown to have higher total energy expenditure (MJ/day), activity energy expenditure, and resting and sleeping energy expenditures than did non-obese children. However, the obese children spent less time in physical activity, more time in sedentary activities, and more time at rest (Maffeis et al., 1996).

The findings of this study found significant negative correlations between step counts and measures of adiposity in boys, including fat percentage, BMI, and fat mass index. However, this is a cross sectional study and therefore the temporal relationship between physical activity and obesity cannot be certain. Nevertheless, similar negative relationship between step counts and BMI was previously demonstrated for American boys ages 11 and 12 years (Vincent et al., 2003). Physical activity was also found to be negatively associated with, while television watching and video game use was shown to positively linked to, being overweight in Canadian children (Tremblay and Willms, 2003). Moreover, in non-obese 6-8-year-old children, it was shown that activity energy expenditure and physical activity levels were negatively associated with body fat (Rennie et al., 2005).

There are several limitations that should be recognized when interpreting the findings from the present study. First, the cross-sectional design of the present study precludes an assumption of causality between inactivity and obesity indices. It remains unclear whether the obesity of boys in this study is due to reduced levels of physical activity or the inactivity is the result of being obese. However, our results are consistent with numerous other studies showing relationships between physical inactivity and adiposity indexes. Second, the convenient sampling in the present study restricts generalization that might be made across the country. Third, pedometer use, though unobtrusive and convenient for the participants, does not measure duration or frequency of activity and is unable to distinguish physical activity intensities during free-living assessment.

In conclusion, the present study reveals a high prevalence of obesity and physical inactivity among Saudi boys aged 8–12 years. In addition, active boys exhibited significantly lower body fat percentage and BMI than inactive peers. Obese boys, on the other hand, were significantly less active than non-obese boys. Increased prevalence of obesity and physical inactivity among Saudi children is a major public health concern. Therefore, concerted efforts are urgently needed to combat childhood obesity, promote physical activity, and discourage sedentary habits among Saudi children and adolescents.

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