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Physical Activity, Physical Fitness and Overweight in Early Schoolchildren

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Abstract

Purpose: The aim of this study was to evaluate physical activity and physical fitness levels in children 7-8 years old with different body mass index (BMI).

Methods: Eighty nine children (age 7.6 ± 0.4) participated in this study. BMI was used as obesity indicator and children were categorized in normal-weight and overweight/obese groups. Daily physical activity was assessed by RT3 accelerometer (Stayhealthy Inc, Monrovia, CA) and physical fitness was assessed using the European physical fitness test battery (Eurofit).

Results: Analysis of variance (ANOVA) indicated no significant differences in the average daily total counts of physical activity and in scores of four fitness tests between the overweight/obese and normal-weight group ($p>0.05$). However, boys were significantly more physically active than girls ($p<0.05$) and the level of physical activity was higher on weekdays than on weekend for both BMI groups ($p<0.05$).

Conclusion: The results indicate that physical activity is not the main contributing factor for childhood overweight at this age. Sufficient levels of daily physical activity were also shown to lead in good physical performance.

Keywords: Childhood obesity; Accelerometer; Physical performance

Introduction

The prevalence of obesity in children (from 6 to12 years old) has been increasing worldwide in the last decades. From 1980 to 2013, prevalence in developing countries has increased in children and adolescents, from 8.1% to 12.9% for boys and from 8.4% to 13.4% in girls [1]. Excess body weight in childhood and adolescence is associated with a higher risk of premature death and disability in adulthood, but overweight children and adolescents are also more likely to develop non-communicable diseases such as diabetes at a younger age [2]. A recent Greek national study which assessed BMI and prevalence of obesity/overweight in a representative sample of 8130 Greek children [3] showed overall 73.7% of the 7-year-olds children retain their classification of weight status at 18 years and a cross-national comparison in the same study confirmed higher levels of overweight youth at 7 years in Greece, compared to England.

The specific causes of overweight and obesity in childhood is complex, but despite the consideration of genetic and physiologic aspects, a reduction in physical activity (PA), an increased amount of time devoted to sedentary lifestyle and increased caloric intake due to environmental changes seem to be important factors for weight gain [4]. While PA levels of adolescents have been studied more frequently because it seems that the decline in PA begins near the onset of puberty, it is unclear whether PA affects weight status at earlier ages. A recent review of cross-sectional studies conducted over the last ten years reported a negative relationship between PA and child weight status in some studies and no association in others [5].

Except PA, a decrease in physical fitness (PF) has been associated with childhood obesity. It has been shown that regular PA in children improves PF, which helps in the management of childhood obesity [6]. The health-related components of PF are cardiorespiratory endurance, muscular strength and endurance, balance and flexibility. Of all these components, only cardiorespiratory fitness has been frequently studied and associated with childhood obesity [7-9]. This may be because of the possible interaction of obesity and cardiorespiratory fitness with cardiovascular disease risks. However in order to design successful interventions and policies to promote PA, PF and reduce childhood obesity, there is a need to better understand how PA and different parameters of PF affect body composition even from a very young age.

To guide the development and implementation of such programs objective measures of PA must be used. Self-report methods that are widely used in many studies for the assessment of PA have the major limitation of inability to accurately recall daily physical activities, especially by young children [10]. Accelerometry provides a unique way to examine associations between body fatness and amount of time spent in activities of varying intensities [11]. Triaxial accelerometers have been developed to detect body acceleration in all three planes and provide more accurate results than uniaxial accelerometers, when assessing PA in children [12-14].

Comparison of habitual PA, assessed with heart rate monitors, between boys and girls has led to conflicting results in the literature. Some studies have reported that boys were more active than girls, whereas others did not find any gender differences [15]. Additionally previous studies using accelerometers for measuring PA have suggested that boys are more active than girls [16] but these findings refer mainly to older children [5,8,10,17]. The patterns of children's PA across days have not been thoroughly examined in younger children [16] despite that weekdays and weekend are likely to provide different opportunities for children to be active [18]. Previous research studies showed controversial results on this subject because of the different habits of children in different age, in different countries [11,15,19]. Hence there is a need of more research on the timing and magnitude of these trends in Greece.

Thus the purpose of this study was to evaluate the association between weight status, PA and PF, in children 7-8 years old with special focus on gender and between days PA differences.

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Material and Methods

Participants

Eighty-nine healthy children (47 boys, 42 girls; mean age 7.6 years, s=0.4) volunteered to participate in this study. BMI was used as an obesity indicator. Using the international cutoff points for BMI, proposed by Cole et al. [20] subjects were classified as normal-weight (NW) (BMI<17.34 kg/m^2) and overweight/obese (OV/OB) (BMI ≥17.34 kg/m^2) groups, according to the age-adapted values. Written informed consent was obtained from parents/guardians of the children. Participants were recruited from a primary school in Serres, Greece. This study was approved by the ministry of education Athens, Greece and by the Research Ethics Board, Aristotle University of physical education, Serres, Greece.

Measures

Height was measured to the nearest centimeter without shoes and body mass was measured to the nearest 0.1 kg with the participants dressed in light-weight clothing. Waist circumference (WC) was also measured and BMI (kg/m^2) was calculated. BMI and WC correlate with cardiovascular (CV) risk factors in children which track into adulthood. WC provides a measure of central obesity, which has been specifically associated with CV risk factors [21].

Accelerometry: Accelerometry was determined using the RT3 accelerometer (Stayhealthy Inc., Monrovia, CA, USA), which measures PA in three individual planes (vertical, X; anteroposterior, Y; mediolateral, Z) and integrates acceleration to yield the "vector magnitude" (VM) calculated as VM= $(X^2+Y^2+Z^2)^{0.5}$. The epoch interval of data collection was set at 1 min. Children were instructed to wear the device to the right side of the anterior torso at the level of the waist. The device was placed into a small bag and on a belt round the waist for safety. Parents were given both verbal and written instructions on how to use the accelerometer and were instructed to put it on the child each morning of the study when the child woke and to remove it during sleeping, bathing, or swimming. Measurements were made for four consecutive days, two school days and a weekend. At least 3 days of recording, with a minimum of 8 hours registration per day, was set as an inclusion criterion. Accelerometry data were downloaded using manufacturers' software. Total PA (TPA) was expressed as total counts recorded divided by total daily registered time (counts/min). The time engaged in moderate PA (MPA) and vigorous PA (VPA) was calculated and presented as the average time per day. The activity counts thresholds for MPA/min was set from 970-2333 counts (3.0 to 5.99 METS) and for VPA/min >2333 counts (>6.00 METS) [22]. All minutes above 970 counts during a day were summarized and expressed as time spent in moderate to vigorous PA (MVPA). Overall mean PA was also compared among weekdays and weekends and among two different genders for two BMI groups.

Assessment of fitness parameters: All participants underwent four fitness tests from Eurofit physical fitness test battery [23]. These included flamingo balance test, sit-and-reach (flexibility), standing long jump (explosive muscular strength) and 10X5m shuttle run (agility). Brief descriptions of the tests follow below.

Flamingo balance test (FBT): This test assesses the strength of the leg, pelvic, and trunk muscle as well as dynamic balance. While balancing on the preferred leg, the free leg is flexed at the knee and the foot of this leg held close to the buttocks. We count the number of falls in 60 seconds of balancing. If there are more than 15 falls in the first 30 seconds, the test is terminated and a score of zero is given.

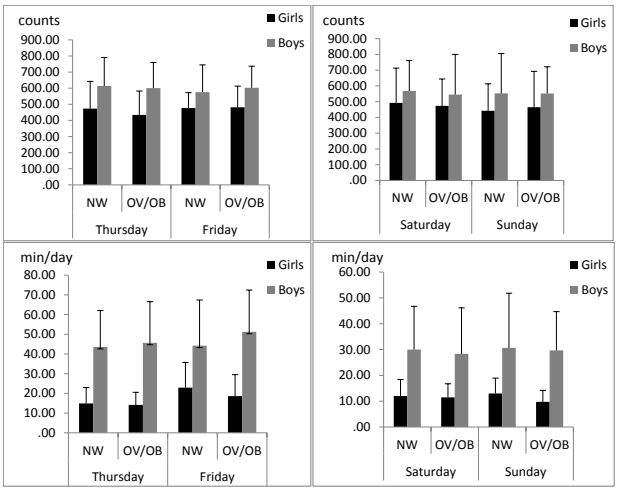

Figure 1: (a) Total physical activity (counts/day) between boys and girls for both BMI groups (b) Vigorous physical activity (min/day) between boys and girls for both BMI groups

Sit and reach (SAR): This test measures the flexibility of the hamstring, buttocks and lower back. It involves sitting on the floor with legs stretched out straight ahead. The soles of the feet are placed flat against a box. With the palms facing downwards, the subject reaches forward along a long ruler, fixed on the box, as far as possible. Indication of 15 cm is at the level of the feet.

Standing long jump (SLJ): Jumping for distance from a standing start. This test measures explosive strength. Children stands behind a line marked on the ground with feet slightly apart. A two foot take-off and landing is used, with swinging of the arms and bending of the knees to provide forward drive. The subject attempts to jump as far as possible, landing on both feet without falling backwards. Two attempts are allowed and the best counts in cm.

10 × 5 meters agility shuttle run (ASR): This test measures speed and agility of lower limb movement. Children stand behind a line and run a distance of 5 meters and back five times (covering 50 meters total). We record the total time taken to complete the 50 m course.

Statistical analysis

All analyses were performed using the Statistical Package for the Social Sciences (SPSS VERSION 17.0) and the level of significance was set as $p< 0.05$. Descriptive statistics for participant characteristics are displayed as means and SD. Pearson correlation was performed to examine the association between BMI and WC. For each of the four days, a Two-way ANOVA was used to examine the differences in TPA, MPA and VPA between the two BMI groups and two genders as independent factors. ANOVA with a repeated measures design was used to examine the differences in mean score of TPA, MPA and VPA of weekdays and weekend between the two BMI groups and two genders (2X2X2). Two-way ANOVA was used to examine the differences between the two BMI groups and two genders in four fitness performances tests.

Percentage frequency analysis was used to evaluate the percentage of the two groups who met the 60-minutes/day MVPA recommendation.

Results

Subjects Participant characteristics are provided in Table 1. Pearson correlation analysis showed a high correlation between BMI and WC (r =0.91, df=87, p<.001).

	Combined	Girls		Boys	
		NW	OV/OB	NW	OV/OB
	n=89	n=20	n=22	n=25	n=22
AGE (years)	7.6 ± 0.4	7.6 ± 0.5	7.5 ± 0.5	7.8 ± 0.4	7.4 ± 0.5
MASS(kg)	30.3 ± 7.0	24.8 ± 3.4	33.7 ± 6.4	27.3 ± 4.0	37.0 ± 7.5
HEIGHT(cm)	128.5 ± 6.9	124.2 ± 5.7	129.3 ± 7.8	128.9 ± 6.5	131.7 ± 6.0
BMI(kg/m²)	18.2 ± 2.8	16.0 ± 1.1	20 ± 2.0	16.4 ± 1.3	21.2 ± 2.4
WEIST CIRCUMFERENCE (cm)	66.6 ± 9.2	59.8 ± 4.7	70.6 ± 7.7	61.1 ± 4.5	77.8 ± 7.0

Table 1: Description of the subjects by gender and BMI categories (mean ± SD).

Physical activity

Two-way ANOVA showed that there were no significant differences in the average daily total counts of PA, between the two BMI groups in each of the four consecutive days (p=0.549, p=0.662, p=0.703, p=0.848 for Thursday, Friday, Saturday and Sunday, respectively). But there were significant differences in the average daily total counts of PA, between two genders for the four consecutive days (p=0.001, p=0.004, p=0.186, p=0.088 respectively). Also there were no significant interaction effect between BMI groups and genders (p=0.767, p=0.761, p=0.973, p=0.835 respectively).

In addition there were no significant differences in the average minutes of moderate (p=0.184, p=0.672, p=0.563, p=0.834 for the four days respectively) and vigorous (p=0.920, p=0.836, p=0.877, p=0.729 respectively) PA between two BMI groups. In contrast there were significant differences in the average minutes of MPA in two from four days (p=0.054, p=0.264, p=0.272, p=0.087 for Thursday, Friday, Saturday and Sunday respectively) and in the average minutes of VPA (p=0.000, p=0.000, p=0.017, p=0.003 respectively) between two genders. Additionally significant differences existed between weekdays and weekend for average total PA counts ($F_{(1,87)}$=12.412, p=0.005), moderate ($F_{(1,87)}$=7.619, p=0.005) and vigorous ($F_{(1,87)}$=16.543, p=0.000) minutes of PA, for both BMI groups and for both genders, who were more active in weekdays than weekend. Specifically, only for VPA, there was significant interaction effect between gender and BMI factors. The results from this analysis are presented in Figure 2.

Physical fitness

Two-way ANOVA showed no significant differences in the four fitness tests parameters between the two BMI groups (p=0.834, p=0.369, p=0.097, p=0.260 for agility, long jump, balance and flexibility respectively). However boys obtained significant better performance than girls in both BMI groups in ASR and in SLJ (p = 0.000 and p=0.009 respectively). In addition there were no significant interaction effect between BMI groups and genders.

Achievement of the health-PA guidelines

Percentage frequency analysis showed that the percentage of NW children who met the international recommendation of 60 min MVPA was from 87.55%-96.9% and the percentage of OV/OB children ranged from 81.5%-96.3% for the four of the measured days (Figure 3).

Discussion

The results from this study suggests that no significant differences existed between NW and OV/OB boys and girls in the average daily counts of TPA or in the average daily minutes of MPA and VPA in early school age. Furthermore, there were no significant differences in scores of four fitness parameters tests, between the two BMI groups. However significant higher activity levels were observed in boys than in girls and significant higher activity levels in weekdays than in weekend in both BMI groups.

There has been considerable interest in the relation between PA and body composition in children but few researchers focused in 6-8-years olds. While it is generally accepted that PA decreases with age [11,16,24], pinpointing the age when the decrease starts and whether this reflects to body composition is important for targeted interventions. To our knowledge the only research in the same age is a recent UK study in 6-8-years olds which had use objective method (Actigraph LLC) of PA measurement and have found association of MVPA with OV/OB boys but not girls [25]. The use of a different model of accelerometer and the use of the specific cutpoint for classifying MVPA, as well as ethnically and socioeconomic criteria may explain these diverse findings. However our findings are in consistent with Thompson et al. [10], Treuth et al. [11] and in part with Mota et al. [8] who used a wide age range. No significant differences were found in objectively measured average daily total minutes of PA or in the average daily minutes of moderate, hard and very hard PA in the normal weight (≤85th percentile), at risk of overweight (>85th till ≤95th percentile) and overweight (>95th percentile) boys and girls 8-17 years old [10]. Similarly, Treuth et al. [11] reported no differences in TPA, MPA and VPA between normal and at risk/overweight boys and girls 7-19 years old. In the other hand Mota et al. [8] found no differences in TPA but significant differences only between non-obese and obese girls 8-15 years old in MVPA. Previous studies which found a negative relation between PA and BMI or body fat, used older children sample and focused specifically on associations of vigorous activity with body fat parameter [17,26-29]. This may have a biological explanation as spontaneous PA observed in young children covers the daily need for vigorous activity. Similarly latest studies in older children showed OV/OB children to be less active than NW children [5,19,30,31]. The contrast in findings from the present study may relate, in part, to the methodology used and the age groups examined. It seems that in that young age, Greek children, both OV and NW, have the time to play and make sport in the afternoon since they have not much homework and other learning obligations as older children do. Additionally, it seems that small cities still offer a safe environment for children's free play. However our finding reinforced by a recent study used questionnaires in 633, 10-12 years old Greek children reported that physical activity was unrelated to overweight [32].

Although health-related PA recommendations for children and adolescents have been established in at least 60 min of MVPA [33], few studies have looked at the relationship between the '60 min' guidelines and body composition. More than 87.55% of non-obese and 81.5% of OV/OB children in our study accumulated 60 or more minutes of MVPA per day. Similarly high compliance with guidelines (95.3% in boys, 77.5% in girls) showed a recent study in 6-12 years old French children [27] and in U.S. Hispanic 4-8 years old children (87%) [24]. Contrary UK studies in 3-5-years olds [34], 6-8-years olds

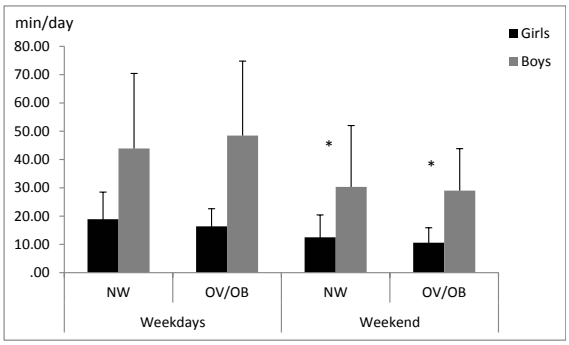

Figure 2: Vigorous PA (min/day) in weekdays and weekend (mean±SD), for both BMI groups and two genders.

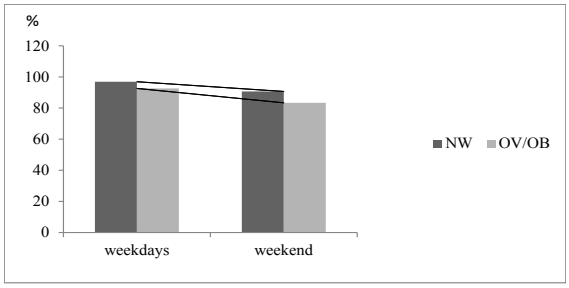

Figure 3: Compliance of NW and OV/OB groups with the international recommendation

and 11-12-years olds [35] which have used objective methods of PA measurement, have found low levels of PA with adherence to the 60 min/day recommendation of MVPA being achieved in <5% of their samples [25]. Low compliance (3% for under/normal weight; 2.6% for overweight/obese) with recommendation was noticed in Kenyan children 9-11-years old [36] in 9 years old children in Spain (37.5% for normal weight and 35% for overweight/obese) [31] and in 10-11 years old children from Malta (39% in boys and 10% in girls) [5]. The reduction of the proportion of children, normal and OV/OB, which meet the recommendation through ages, is clear as well as ethnically differences between studies. In our study it seems that the absence of a large number of obese children (only 8 in 89) combined with the intensity threshold used for vigorous intensity and the very good PA status of our cohort, affected the results on this parameter.

In this study we also examined the relation of overweight/obesity with selected fitness parameters. Most studies that have investigated differences in PF according to body fatness have focused on cardiorespiratory fitness. However we selected tests on agility, balance, flexibility and strength because as it is written before "activities of children aged 6 to 9 years are large anaerobic, and they help the child learn basic and more specialized motor skills" [37]. Additionally there is a subsidiary recommendation for activities which help children to enhance muscular strength and flexibility, at least twice a week [33]. We found no significant differences in flexibility test between the two BMI groups. These findings are in agreement with the findings of previous researchers [38-43]. On the balance test scores for the obese subjects in the present study were similar to those for their nonobese peers. Based on German BMI references (≥90 percentile overweight/obese) significant differences were found only between the obese and underweight 6-8 years old children [39]. Another study showed inferior scores for the obese subjects to those for their nonobese peers in balance but in an older sample [38], in contrast to Raudsepp et al. [44] who found no correlation between fatness and balance in prepubertal girls [44]. In the present study NW and OV/OB subjects had similar scores in weight-bearing activities, such as standing-broad jump and speed shuttle run. Other investigators have reported inferior performances for the obese subjects on these tests, compared with their non-obese counterparts [38,41,42], while Brunet et al. [43] reported significant differences, between the two BMI groups, in the scores of two tests only for children over 8 years old and Graf et al. [39] only between obese and normal/underweight children in SLJ. We must underline the significant better performance were observed in our study, in boys than in girls in SLJ and in ASR, in both BMI groups. Gender differences and better PA levels in boys probably explains these findings. However, it seems that the good level of PA for both BMI groups is a protecting factor to improve PF among children in that young age.

Our results corroborate previous observations consistently demonstrating that boys are more physically active than girls [8,11,16,17,24,26,28,29,45-47]. It was suggested that differences in gender roles (e.g. boys participating in higher energy expending roles or activities), and a higher motivation inherent in boys to participate in physical activity, may explain this sex difference [36].

Both sexes took part in significantly more PA on weekdays than weekends, highlighting the role the school environment plays in maintaining activity levels, and that more needs to be done to increase activity on weekends. These findings are in consistent with some previous studies [11,15,18,35,48] in contrast with another [31,49] whereas a study suggested similar activity pattern between weekdays and weekend [35]. Inconsistent results may exist due to geographical location, including environmental and socio-cultural factors.

Some limitations of the study should be recognized. Although accelerometry has been used to provide measures of intensity and duration of PA, current data cannot describe what the participants are doing while they are sedentary and cannot assess some activities like swimming and cycling. The study included primary-school children from one urban area only, which make difficult to generalize the findings. In addition, some limitations must be assumed when the current PA outcomes are compared with those of other studies because several factors such as type of monitor, length of the epoch and cut-off points selected. Furthermore, it is not possible to infer causal relationships using such a cross-sectional design. Therefore, longitudinal studies with more obese (>95th percentile) subjects should evaluate the effect.

Conclusion

This study pointed out an influence of gender and of the type of day on PA behavior of early schoolchildren. A high percentage of Greek 6-8 year olds (normal weight and overweight/obese) reached the recommended levels of daily MVPA. In contrast, overweight early schoolchildren appeared not to display different physical activity and fitness profiles compared to their peers. Therefore, if any, the effect of reduced physical activity levels on childhood obesity may be the result of a long term process, perhaps in combination with other factors. Early detection of weight status and physical performance, are important so that those in need of intervention can be targeted as early as possible.

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