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Research Article / Araştırma Makalesi

Association of physical activity level with body composition in 12-14 years old children: A pilot study

12-14 yaş aralığındaki çocukların fiziksel aktivite düzeyi ve vücut kompozisyonu arasındaki ilişki: Pilot çalışma

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ABSTRACT

Objective: The prevalence of overweight and obesity among children and adolescents increased dramatically. Reduced regular physical activity (PA) is considered one of the major factors behind this worldwide epidemic and related health problems. This study aimed to determine the association between PA level and body composition components in 12-14 years old girls and boys living in Altındağ district, Ankara.

Materials and methods: A total of 234 boys and 224 girls aged 12-14 years participated in this study. PA level was assessed by the Physical Activity Questionnaire for Children (PAQ-C) and body composition was measured by bioelectric impedance. Two-way ANOVA with Bonferroni post hoc test and Pearson Correlation Coefficient tests were used in data analysis.

Results: Findings of the study showed that children aged 12 years had higher total PA score than aged 13 and 14 years ($p<0.05$), showing decreased PA level with age. Boys had significantly higher total PA score in all age groups than girls ($p<0.05$). Girls with healthy weight and overweight showed significantly higher total PA score than girls with obesity. Girls had higher fat mass and body fat percentage than boys in all age groups ($p<0.05$). Fat mass was inversely associated with total PA score in all age groups (12 years old $r=-0.28$; $p<0.001$, 13 years old $r=-0.16$; $p=0.047$, 14 years old $r=-0.21$; $p=0.007$).

Conclusions: PA participation of children declines with age. Reduced PA level is significantly associated with increased fat mass, indicating the importance of PA in maintaining a healthy weight in this age group.

Keywords: *Body composition, lean mass, fat mass, physical activity*

ÖZ

Amaç: Aşırı kilo ve obezite prevalansı, çocuk ve ergenler arasında çarpıcı bir şekilde artmıştır. Düzenli fiziksel aktivitenin azalması, dünya çapındaki bu salgın ve ilişkili sağlık sorunlarının arkasındaki ana faktörlerden biri olarak kabul edilmektedir. Bu çalışmanın amacı, Ankara'nın Altındağ ilçesinde yaşayan 12-14 yaş arası çocuklarda fiziksel aktivite düzeyi ile vücut kompozisyonu arasındaki ilişkiyi belirlemektir.

Gereç ve Yöntemler: Bu araştırmaya, 12-14 yaş arası 224 kız ve 234 erkek katılmıştır. Fiziksel aktivite düzeyi Çocuklar için Fiziksel Aktivite Anketi (PAQ-C) ile, vücut kompozisyonu ise biyoelektrik impedans analizi ile belirlenmiştir. Veri analizinde iki yönlü varyans analizi, Bonferroni post hoc testi ve Pearson korelasyon katsayısı testleri kullanılmıştır.

Bulgular: Bu araştırmanın bulguları, 12 yaşındaki çocukların fiziksel aktivite puanlarının, 13 ve 14 yaşındakilere göre daha yüksek olduğunu ($p<0.05$) ve yaşla birlikte fiziksel aktivite düzeyinin azaldığını göstermiştir. Erkeklerin her yaş grubunda kızlardan daha yüksek fiziksel aktivite puanına sahip olduğu görülmüştür ($p<0.05$). Normal ve fazla kilolu kızlar, obez kızlara göre daha yüksek fiziksel aktivite puanına sahiptir. Her yaş grubu için, kızlarda yağ kütlesi, erkeklere göre daha yüksek bulunmuştur ($p<0.05$). Tüm yaş gruplarında yağ kütlesi, fiziksel aktivite puanı ile negatif korelasyon göstermektedir (12 yaş $r=-0.28$; $p<0.001$, 13 yaş $r=-0.16$; $p=0.047$, 14 yaş $r=-0.21$; $p=0.007$).

Sonuç: Fiziksel aktiviteye katılım yaş arttıkça azalmaktadır. Azalmış fiziksel aktivite düzeyinin yağ kütlesi ile ilişkili olması, fiziksel aktivitenin bu yaş grubunda sağlıklı vücut ağırlığını korumadaki rolünün önemini göstermektedir.

Anahtar Sözcükler: *Vücut kompozisyonu, kas kütlesi, yağ kütlesi, fiziksel aktivite*

INTRODUCTION

A physically active lifestyle has many benefits for health at all stages of life (1, 2). According to the World Health Organization, children and adolescents aged 5 through 17 years should do 60 minutes or more of daily moderate or vigorous-intensity physical activity (PA) (3). Children and adolescents engaging in regular PA are known to have a range of benefits during childhood including healthy growth, development of the musculoskeletal and cardiorespiratory systems, and maintenance of energy balance (4). In addition, PA significantly improves well-being, strength, and flexibi–

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lity in all age groups (5). Also, enhancing PA level in the early years of life overcomes childhood obesity (6) as well as helps lay the foundation for a healthy and active life across the lifespan (7). On the other hand, epidemiologic data reports that reduced PA level and increased sedentary behavior are associated with many health problems, including type 2 diabetes and cardiovascular diseases in children and adolescents (8). Furthermore, the prevalence of overweight and obesity among children and adolescents aged 5-19 increased dramatically between 1975 and 2016, from 4% to over 18%, respectively (9).

Reduced regular PA is accepted as one of the major factors behind the obesity pandemic and related health problems (10). Although PA declines throughout the lifespan, cross-sectional and longitudinal studies have suggested that the decline in PA is greatest during adolescence and that girls are more inactive than boys at all ages (11). According to the reports (12), the global prevalence of insufficient PA (80% of the adolescents) among children and adolescents aged 11-17 years have remained unchanged over the last decade. In 2016, it was reported that globally more than 81% of adolescents (85% of girls and 78% of boys) were not active enough according to a study based on 1.6 million 11-17 years old adolescents across 146 countries (1) and this case is likely to cause severe health issues later in life. For instance, being obese in childhood increases the risk of being obese as an adolescent and adult as well as the risk of cardio-metabolic diseases. From this point of view, assessing the association between obesity and PA level in this group is of significant importance.

Due to its ease of use and standardization, the body mass index (BMI) is widely used as the standard measurement proxy for defining anthropometric characteristics in adults (4). However, it is increasingly clear that BMI is a poor indicator of fat mass (FM) (13) and that the body fat percentage (BFP) for any given BMI value varies greatly among individuals based on age, sex, and ethnicity. Furthermore, since a higher BMI may be associated with increased FM or lean mass (LM) (14), the association between PA level and BMI is likely to result in conflicting results. In particular, the contributions of FM and LM to body weight may vary by age, sex and maturation status during childhood and adolescence (15), BMI can comprise a wide range of BFP in children aged 8-12 years. On the other hand, most of the studies investigating the overweight and obesity in adolescents rely on BMI (16-18); hence, measurement of other body components, including FM and LM would enable a proper interpretation of body composition (BC) that is known to differ according to the PA level in children and adolescents. Research that aimed to reveal the association between PA and BC components in adolescents reported that adolescents who regularly engaged in moderate and vigorous-intensity PA had increased LM and reduced FM (19). A longitudinal study that followed BC, PA, and stature for 6 years, reported that habitual PA positively affected the development of LM in adolescents (20). Despite the current knowledge indicating the importance of regular PA in childhood and adolescence in the development of a healthy BC, there is a limited number of studies investigating this relationship and the age and gender differences in PA in 12-14 years old girls and boys in Turkey. Therefore, this study aimed to investigate the association between PA level and BC components and age and gender-related differences in PA levels in 12-14 years old children in Altındağ district, Ankara.

MATERIALS AND METHODS

Participants

A total of 234 boys and 224 girls aged between 12 and 14 were included in this study (mean age: 13.1±0.8 years). Since the included students were chosen from the same district, Altındağ, in Ankara, they were supposed to have similar socioeconomic status. The students participating in the study were healthy and not having any regular medical treatment based on self-reported questionnaire. The procedure of the study was explained to the students and their families and written informed consent was obtained from the students and their parents. The study was approved by Non-interventional Clinical Research Ethics Board of Hacettepe University (Approval number: 2021/07-26).

Assessment of physical activity level

Physical activity level of participants was assessed by the Physical Activity Questionnaire for Children (PAQ-C) developed by Kowalski et al. (21). The PAQ-C questionnaire was originally designed for children aged 8 to 14 and consists of nine questions structured to discern low (score 1) to high (score 5) PA during the last seven days and the tenth question in order to identify children or adolescents who had unusual activity during the previous week. However, the last question is not evaluated as a part of the total activity score. The first question of PAQ-C contains a checklist of 22 common leisure and sports activities as well as two “other” fill-in choices. The first question is scored as the mean of all activities by a score from 1 to 5, where 1 indicates low PA, whereas 5 indicates high PA. The total score of these questions except the last question is calculated by adding all the questions’ average scores. The validity and reliability of the questionnaire were adapted to the Turkish community by Sert et al. (22). Before the BC measurement, the students were asked to fill out the questionnaire in the classrooms, along with two researchers who were always present to make sure that all students answered the questions after they fully understood.

Assessment of body composition

Body composition measurements were performed in the morning after completion of the PAQ-C in the classrooms. Participants' height, body weight and BC were measured by two experienced examiners according to the standard procedures. Height was measured with a portable stadiometer to the nearest of 0.1 cm (Leicester Height Measure Mk II, Child Growth Foundation) and body weight (BW), FM, fat-free mass (FFM), and LM was determined without shoes, socks and heavy clothing by using bioelectric impedance analyzer to the nearest 0.1 kg (BIA, Tanita TBF-SC330, Japan). BMI was calculated as weight/height^2 (kg/m^2) and BMI percentiles were derived from data from the Centers for Disease Control and Prevention Growth Charts (23). This formula separates children and adolescents into four different BMI categories, showing BMI<5th percentile as being underweight, 5th≥BMI≤84th percentile as being healthy weight, 85th≥BMI≤94th percentile as being overweight, and BMI≥95th percentile as being obese (24).

Statistical analyses

The sample size was calculated using the statistical program (25) that showed minimal 380 participants were needed, considering the population size of Altındağ district in Ankara, %50 of anticipated frequency of outcome factor in the population, confidence level of %95, the margin of error of 5%, and a design effect of 1. All data were checked for normality by the Kolmogorov–Smirnov test. Descriptive statistics were calculated as means and standard deviation (SD) by gender and age. A two-way ANOVA test (gender x age) was used to analyze the data with Bonferroni post hoc analysis performed on each pair of groups. Pearson correlation coefficients were computed for total PA score, BMI and BC components by gender and age. All statistical analysis was performed using SPSS Statistics for Windows, Version 21.0 (IBM Corp., Armonk, NY, USA). Significance was set at an alpha level of p< 0.05.

RESULTS

Body composition variables are presented in Table 1. According to the BMI percentile classification, 66.1% of girls and 61.5% of boys had healthy weight, 21.0% of girls and 17.5% of boys were overweight, 12.9% of girls and 17.9% of boys were obese and %3 of boys were underweight. There was no underweight girl (Table 1). Boys had significantly higher total PA score (PAS) at all age groups than girls (p<0.05; Figure 1). Total PAS was higher in boys and girls aged 12, compared to those of 13 and 14 years old (p<0.05; Figure 1), showing decreased PA level with age.

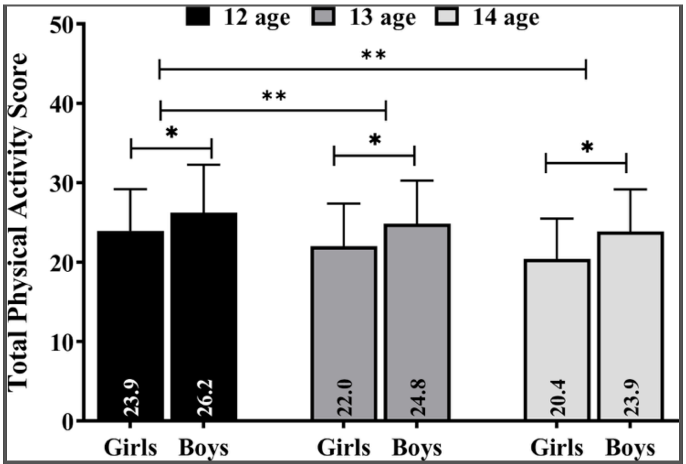

Figure 1. Total physical activity score by age and gender

** p<0.05, Significant difference between genders at all age groups. ** p<0.05, In both genders, the age of 12 is significantly different from the ages of both 13 and 14 years.*

Concerning all of the participants, total PAS was similar by bodyweight categories defined as healthy weight, overweight and obese (p>0.05; Figure 2). Boys with healthy weight and obesity had higher total PAS compared to girls with the corresponding weight categories (p<0.05), while no gender difference was found in overweight groups (p>0.05; Figure 2). Girls with healthy weight (Total PAS= 22.09 ± 5.56; p=0.050) and overweight (Total PAS= 22.97 ± 4.83; p=0.019) had higher total PAS compared to girls with obesity (Total PAS= 19.48 ± 4.82; Figure 2). No difference was found in the PAS of boys by the bodyweight categories (p>0.05; Figure 2).

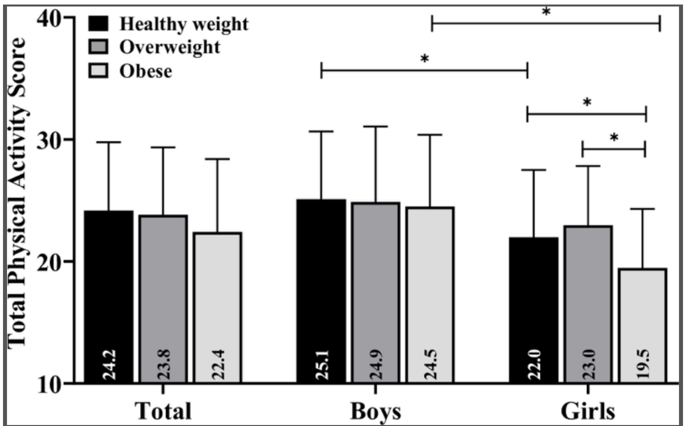

Figure 2. Total PAS by the BMI classification and gender (*p<0.05)

Body weight increased with age both in girls and boys (p<0.001; Table 1), except for girls aged 13 and 14 who had similar BW (p>0.05). BMI and BMI percentile values were similar between the age groups and the genders (p>0.05;

Table 1). The only exception was that girls aged 12 years had significantly lower BMI than girls aged 14 years (p=0.006; Table 1). LM and FFM tended to increase with age in both genders. In boys, FFM and LM were significantly different by age groups (p<0.001). Although both 13 and 14 years old girls had significantly higher FFM and LM compared to 12 years old girls (p<0.001), no significant difference was observed between the 13 and 14 years old girls. Boys had higher LM and FFM in all age groups than girls. However, the difference was statistically significant for 13 and 14 years old (p=0.001 and p<0.001, respectively), not for 12 years old (FFM p=0.093, LM p=0.075; Table 1). FM was significantly higher in girls than boys in all age groups (p<0.05; Table 1). Both boys and girls at 12 years old had significantly lower FM compared to those of 13 and 14 years old (p<0.05; Table 1). BFP was significantly higher in girls than boys regardless of the age groups (p<0.05; Table 1), while no significant difference was observed between the age groups in girls and boys (p>0.05; Table 1).

Table 1. Comparison of body composition variables by age and gender

Variables	12 years old		13 years old		14 years old	
	Girls (n=61)	Boys (n=74)	Girls (n=76)	Boys (n=80)	Girls (n=87)	Boys (n=80)
Height (cm)	152.8±6.9	150.1±7.3	157.3±6.2	157.1±8.5	158.2±5.7	162.2±8.4
BW (kg)$^{€\ t}$	46.7±11.6	45.3±10.6	54.6±11.3	51.7±13.1	55.9±11.6	56.9±14.3
BMI (kg/m²)$^{\#}$	20.1±3.5	20.7±4.4	21.9±3.5	20.8±4.0	22.3±4.2	21.4±4.3
BMI percentile	63.2±27.7	67.0±27.2	71.6±24.3	63.0±31.4	67.2±26.9	61.4±29.8
FM (kg)^{*t§}	11.6±6.9	8.6±5.6	15.5±6.7	9.2±5.8	15.8±7.5	8.9±6.7
FFM (kg)$^{€\ t\ ¥}$	35.0±5.1	36.7±6.1	39.0±5.0	42.7±7.7	40.3±4.7	48.2±8.5
LM (kg)$^{€t\ ¥}$	33.2±4.8	34.9±5.7	37.0±4.7	40.2±7.9	38.1±4.3	45.6±8.4
Body fat (%)*	23.4±6.9	17.6±7.7	27.2±6.5	16.6±6.8	27.0±7.1	14.2±7.3

BW; body weight, BMI; body mass index, FM; fat mass, FFM; fat-free mass, LM; lean mass. Mean±SD

$^{€}$ p<0.05; Significant difference between age groups in boys.

^{t} p<0.05; Age 12 is significantly different from the ages of 13 and 14 in girls.

§ p<0.05; Age 12 is significantly different from the ages of 13 and 14 in boys.

$^{\#}$p<0.05; Significant difference between 12 and 14 years old girls.

*p<0.05; Significant difference between genders in all age categories.

$^{¥}$ p<0.05; Significant gender differences for 13 and 14 years.

The correlation coefficients between total PAS and BC variables for the girls and boys are presented in Figure 3. Accordingly, total PAS was inversely correlated with FM and BFP in 12 years old (FM r=-0.28; p<0.001 and BFP r=-0.28; p<0.001; Figure 3A-B) and 13 years old girls and boys (FM r=-0.16; p=0.047 and BFP r=-0.21; p=0.01; Figure 3C-D). Total PAS was negatively associated with FM (r=-0.21; p=0.007; Figure 3E) and positively associated with LM (r=0.19; p=0.01; Figure 3F) in 14 years old girls and boys.

DISCUSSION

The findings of this study showed that BW significantly increased with age in children aged 12-14 years. FM and BFP were higher in girls, whilst LM and FFM were higher in boys than girls regardless of age. Total PAS was higher in boys than girls and similarly decreased with age in both genders. Total PAS was negatively associated with FM in 12 years old girls and boys and was positively associated with LM in 14 years old. Girls with healthy weight and overweight had higher total PAS compared to girls with obesity, while this difference was not evident within boys.

Physical inactivity is one of the leading causes of major chronic diseases (26). Ample evidence shows that a physically active lifestyle should start from childhood and continue throughout adulthood for the health of the individuals and populations (27). However, contrary to this notion, PA participation was reported to decline with age during adulthood (28), and girls are less active than boys in most countries (29). In the present study, we found that total PAS was higher in boys than girls regardless of age, in agreement with some published studies (30-32). A recent study supporting the findings of the current study that was conducted in 146 countries between 2001-2016, showed that girls in 142 countries were less active than boys (1). Given that advanced pubertal maturation in girls results in a decline in PA (33), biological factors are accepted as the most cited reason for this more profound decline in PA in girls. In addition, we found that total PAS decreased with age in both sexes, which is similar to the data reported in a large and cross-sectional observational study from the National Health Interview Survey using the 1992 Youth Risk Behavior Survey supplement for adolescents that reported participation in regular PA consistently decreases from ages 12 through 21 (30).

Regarding BC, we documented a marked increase in BW, FM, LM, and BMI with age in boys and girls, similar to the existing studies (20, 34). As expected, this observed increase in BC components is in conjunction with growth that produces changes in FM, BFP and LM during childhood

(34). Based on the BMI percentile classification, we found that 66.1% of girls and 61.5% of boys were with healthy weight, 21.0% of girls and 17.5% of boys were overweight, and 12.9% of girls and 17.9% of boys were obese. These results are consistent with other studies that have reported similar results on the prevalence of obesity in this age group (35, 36). Besides, it is well documented that PA is of pivotal role in the prevention of high adiposity levels and obesity (37). However, BMI is not a sufficient indicator to evaluate obesity in all age groups, necessitating consideration of BC to more accurately assess body fatness (37). For this reason, we also assessed FM, LM, and BFP of boys and girls using BIA. Our findings showed that FM and BFP were higher in girls, while boys had higher LM, which were independent of the age categories. Similarly, Moliner-Urdiales et al. (32) reported that boys (12.5-17.5 yrs) had higher FFM than girls (32). Another study carried out on 445 adolescents by Ekelund et al. (31) revealed that 17 years old girls had higher FM than boys who had greater FFM (31). These differences between the genders can be, in part, explained by the differences in the relative time spent in vigorous PA. A meta-analysis on gender-related differences in PA and body fatness concluded that there is a significant and negative association between PA-related energy expenditure and BFP in males but not in females (38). Additionally, a study revealed that adolescent girls have a higher risk for FM accumulation due to their reproductive capacity (39).

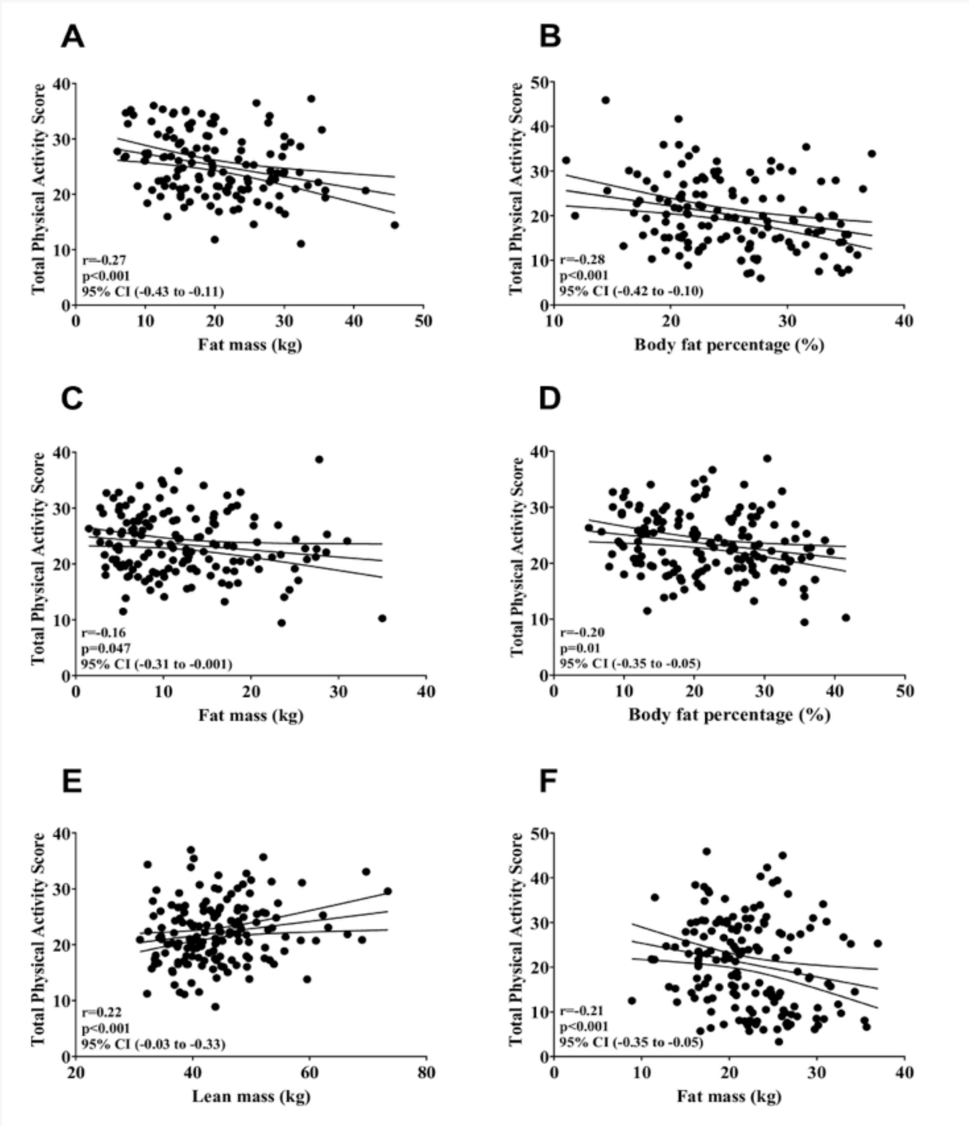

Figure 3. Significant correlation coefficients between total PAS and body composition variables; total PAS with fat mass (A) and body fat percentage (B) for age 12, total PAS with fat mass (C) and body fat percentage (D) for age 13, total PAS with body fat percentage (E) and lean mass (F) for age 14. CI; confidence interval.

We found an inverse significant association between PA level and FM in participants aged 12 years and a positive association of PA level with LM and FFM in participants aged 14 years. These results are supported by a systematic review which reported a significant negative association between PA and adiposity in children and adolescents in 79% of the included studies (40). Likewise, Ekelund et al. (29) also found that total PA level was significantly and inversely associated with FM in males (r= -0.20, p<0.01) but not in females. We showed that girls with healthy weight and overweight had higher total PAS compared to girls with obesity, revealing a negative association between the total amount of PA time and BW. This finding was supported by a systematic review on PA and adiposity that reported a negative significant association between measured PA and adiposity (19).

Based on the findings from the current and existing studies (41, 42), school-based PA interventions are of primary importance for increasing the number of children engaged in PA, which in turn reduces adiposity. However, increasing PA among children and adolescents is difficult as there might be some impediments to PA. Therefore, the school setting is an ideal environment for population-based PA interventions, since no other institution has much influence on children during their first two decades of life (41).

Several limitations should be considered in interpreting the findings of the present study. First, we assessed the BC of participants via BIA based on the 2-compartment model which partitions the body into FM and FFM. However, the 4-compartment BC model involving the measurement of body weight, total body water, and bone mineral content would provide a more accurate measure of BC. Secondly, we did not control some confounders, such as sleep duration, diet, and genetic variations. Additionally, the data collection was based on a classroom setting and self-reported questionnaire, further studies should consider tracking PA levels with accelerometers that would provide more precise data. Further studies are needed to control the unmeasured confounders, such as dietary, PA, and sedentary behaviors associated with BC with the use of a larger sample with sufficient power to increase the likelihood of finding other significant effects.

CONCLUSION

This study indicates that PA participation declines with age in 12-14 years old girls and boys, and that girls have a considerably lower level of PA compared to their male counterparts. Besides, girls have higher FM and BFP, whilst boys have higher LM. Reduced PA level is significantly associated with increased FM.

Ethics Committee Approval / Etik Komite Onayı

The approval for this study was obtained from Clinical Research Ethics Board of Hacettepe University (Approval number: 2021/07-26, Date: 30.03.2021).

Conflict of Interest / Çıkar Çatışması

The authors declared no conflicts of interest with respect to authorship and/or publication of the article.

Financial Disclosure / Finansal Destek

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Author Contributions / Yazar Katkıları

Concept: HHT, ŞNK; Design: YG, ŞNK; Supervision: HHT, ŞNK; Materials: YG, ŞNK; Data Collection and/or Processing: YG, MMA, HHT, ŞNK; Analysis and Interpretation: YG, MMA, ŞNK; Literature Review: YG, MMA; Writing Manuscript: YG, MMA, ŞNK; Critical Reviews: YG, MMA, HHT, ŞNK.

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