The Turkish Journal of Pediatrics 2024; 66: 511-524
https://doi.org/10.24953/turkjpediatr.2024.5300

Original Article

Differences in physical activity, sedentary time, and anthropometric variables among children and adolescents: The TUBON project

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ABSTRACT

Background. Although physical inactivity may lead to increasing obesity prevalence, research on anthropometric variables changes based on physical activity (PA) in children and adolescents is limited. PA decreases with age, while sedentary behavior increases. The study aimed to examine differences in objectively measured sedentary time, light-intensity physical activity (LPA), and moderate-to-vigorous intensity physical activity (MVPA) between children and adolescents, and the differences in the percentiles of anthropometric variables between physically active and inactive groups according to World Health Organization PA recommendations.

Methods. A total of 759 participants aged 6-17 years (boys, n=358; girls, n=401) were included in the study. The ActiGraph wGT3x-BT accelerometer was used to measure sedentary time, LPA, and MVPA. Height, weight, waist circumference (WC), triceps skinfold thickness (T-SFT), and medial-calf skinfold thickness (M-SFT) were measured. Body fat percentage (BF%) and body mass index (BMI) were calculated, and the percentiles of anthropometric variables were categorized.

Results. The findings showed that children had less sedentary time and a higher LPA than adolescents for both genders ($p<0.05$). Children had a higher MVPA than adolescents in girls ($p<0.05$), but the difference was insignificant in boys ($p>0.05$). In boys, physically active children were in lower percentiles for T-SFT and BF% than those who did not ($p<0.05$). In boys, adolescents who were physically inactive were in higher percentiles for BMI, T-SFT, M-SFT, and BF% ($p<0.05$). In addition, in girls, adolescents who were physically active were in lower percentiles of BMI, M-SFT, and BF%, whereas children who were physically active were in lower percentiles of M-SFT and BF% ($p<0.05$).

Conclusion. Sedentary time increases while PA decreases with age. Children and adolescents who met the WHO PA recommendation had lower percentiles of anthropometric variables, indicating the importance of PA in preventing obesity in these age groups.

Key words: physical activity, sedentary time, anthropometry, children, adolescents.

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Received 8th Sep 2024, revised 21st Oct 2024, accepted 29th Oct 2024.

Children and adolescents should do at least 60 minutes per day of moderate-to-vigorous intensity physical activity and bone-strengthening activities at least three days a week.[1] Also, replacement of sedentary time with light-intensity physical activity and moderate-to-vigorous intensity physical activity is recommended for health benefits.[1] Sedentary behavior is any activity performed while sitting, lying down, or reclining and characterized by an energy expenditure of 1.5 metabolic equivalents (METs) or less. Light-intensity physical activity is between 1.5 and 3 METs, while moderate-to-vigorous intensity physical activity includes intensities above 3 METs.[1] Physical activity is crucial for improving cardiometabolic and bone health, and body composition in children and adolescents.[2,3] Moderate-to-vigorous intensity physical activity may reduce body fat in individuals with high body fat[4], potentially preventing obesity in children and adolescents.[1] Sedentary time is positively associated with overweight and obesity.[5] Increased sedentary time negatively impacts body mass index (BMI), waist circumference (WC), and fat mass index.[6,7] Strategies to prevent excessive adiposity in children and adolescents include increasing light-intensity physical activity with reduced sedentary time.[8] Research has highlighted light-intensity physical activity due to its role in reducing sedentary behavior and increasing physical activity levels.[9,10] Light-intensity physical activity is an important part of daily physical activity and is characterized by the borderline of sedentary time and moderate-to-vigorous intensity physical activity. Although light-intensity physical activity accounts for the majority of daily physical activity and contributes to an increase in daily energy expenditure, more research is needed on its beneficial effects on health.[9]

Jiménez-Pavón et al.[11] showed that higher physical activity reduced fat mass in adolescents. Conversely, conflicting results exist regarding the effects of physical activity on obesity indicators such as BMI and fat mass.[12] A review by Janssen and Leblanc[13] found weak associations between physical activity and obesity in school-aged children. Additionally, studies on changes in anthropometric variables based on objectively measured physical activity and sedentary time in prepubertal children are limited.[6] Further research is needed to understand the difference in anthropometric variables based on physical activity. Current physical activity guidelines have several limitations, such as self-reported assessment and inadequate addressing of cardiovascular disease risk markers.[14] Accordingly, there is insufficient evidence to fully define dose-response relationships between physical activity and health outcomes.[15] To the best of our knowledge, few studies have compared anthropometric variables in children based on physical activity recommendations. Further research is needed also on the percentiles of anthropometric variables relative to physical activity guidelines.

Previous studies suggest a decline in physical activity and an increase in sedentary behavior from childhood to adolescence.[16,17] Although it is suggested that the most significant decline occurs during adolescence, evidence indicates that it may occur earlier.[4] Identifying adolescents based on biological maturation is critical, but age-based identification is often used. The World Health Organization (WHO) classifies adolescents as those aged 10 to 19 within the broader category of children aged 5 to 19 years.[18] However, discrepancies between adolescent and childhood age ranges in physical activity and sedentary time research[16,19] suggest the need for further studies using age definitions of the WHO. Taken together with this rationale, it seems important to compare obesity indicators according to whether the physical activity recommendation is met or not, which is limited in the literature. Therefore, the study aimed to compare objectively measured sedentary time and physical activity levels according to the age groups of children and adolescents and to compare the percentiles of anthropometric variables according to whether they met physical activity recommendations in children and adolescents.

Materials and Methods

Participants

The study included 891 healthy children and adolescents aged 6 to 17 years from the provinces of Ankara, Kırıkkale, Bartın, Ordu, Eskişehir, Antalya, İzmir, İstanbul, Batman, Mardin, Van, and Ağrı, representing 11 of the 12 regions of Türkiye from 27th September 2022, through 3rd June 2023, according to the Nomenclature of Territorial Units for Statistics Level 1 (NUTS-1). However, 132 participants who did not meet the wearing criteria for accelerometer data were excluded; therefore, the present study included 759 healthy children and adolescents. Participants with physical, visual, hearing, or intellectual disabilities, chronic illnesses, and an electronic or other medical implant in their body were excluded from the study. The data for this study were obtained from the TUBON project (see https://tubon-projesi.hacettepe.edu.tr/tr) funded by the Scientific and Technological Research Council of Türkiye (TÜBİTAK, project number: SBAG 120S408). The sample of TUBON project was randomly selected from twelve provinces, including primary, secondary, and high schools affiliated to the Ministry of National Education of the Republic of Türkiye. In the sampled schools, the classes for each grade were listed. From each grade, the classes were randomly selected using simple random sampling. A list of students in the selected classes was prepared, and 10% of the list of participants recruited by stratified random sampling by gender was randomly selected. The accelerometers were only worn by approximately a 10% subgroup (n=759) of the TUBON project, not the whole sample (n=7659), due to the high cost of the ActiGraph wGT3x-BT. Therefore, the sample of this study consists of the accelerometer data collected from approximately 10% of the sample of the TUBON project. The study was conducted in accordance with the ethical standards of the Declaration of Helsinki, and participants and their parents signed an informed consent form. This study was approved by the Non-Interventional Clinical Research Ethics Board of Hacettepe University.

Data collection

The researchers provided participants with consent and demographic information forms. Participants who agreed to participate and had parental consent completed the health information forms. Then participants were asked to wear the accelerometers. Researchers explained the purpose of the study and tests, and the physician examined the participants before conducting anthropometric measurements.

Demographic and health information forms

Demographic information was collected from participants and their parents. The parents filled out demographic information forms for themselves. Parents also filled out the form for their 6 and 10-year-old children, and children over 10 filled it out for themselves. The form asked about the participants' history of cyanosis, palpitations, and dizziness during physical activity and any family history of sudden death under the age of 45.

Anthropometric measurements

Participants were instructed to wear light, comfortable clothes before the anthropometric measurements. Height, sitting height, and body weight were measured twice, with the highest value used for analysis. Skinfold thickness measurements were also performed twice, with a third measurement if the difference between two measurements was greater than 10%.

Height and sitting height were measured with a portable stadiometer (SECA 217, Germany) to 0.01 m accuracy. Height was measured with subjects standing without shoes, after a deep inhalation, and with the head in the Frankfort plane.[20] Body weight was measured to the nearest 0.1 kg without shoes using bioelectrical impedance analysis (Tanita MC580, Japan).[20] BMI was calculated (kg/m^2) based on height and weight.

The study utilized a Holtain skinfold caliper (Holtain Ltd, Crymych, United Kingdom) to measure triceps skinfold thickness (T-SFT) and medial-calf skinfold thickness (M-SFT), with each measurement taken twice and averaged. T-SFT was assessed at the midline of the upper arm, between the acromion and olecranon processes.[21] For M-SFT, the medial (inside) of the calf was marked for the maximal circumference measurement. A vertical skinfold was grabbed and measured with a caliper approximately 1 cm proximal to the specified point.[20,22] Body fat percentage (BF%) was estimated using equations by Slaughter et al.[23] for children aged 8–18 years and Dezenberg et al.[24] for children under eight years.

The equations are as follows:

For children aged 8–18 years:

[*Males* = 0.735 *(triceps+calf)*+1.0*), Females* = 0.610 *(triceps+calf)*+5.1]

For children under eight years of age:

(0.342**body weight*+0.256* *triceps*+0.837**gender*-7.388)

WC was measured to the nearest 0.1 cm at the narrowest part of the waist using a Gullick meter and recorded in centimeters.[20,21] WC were performed twice, and the average of the two measurements was used in the statistical analysis.

In this study, BMI and WC percentiles were derived from the Centers for Disease Control and Prevention's (CDC) Anthropometric Reference Data for Children.[25] T-SFT and M-SFT percentiles were based on the study reference by Cicek et al.[26] and Kuhle et al.[27], respectively. BF% percentiles were based on Soylu et al.'s data for Turkish children and adolescents.[28] BMI was categorized as underweight (<5th percentile), healthy weight (5th-84th percentile), overweight (85th-94th percentile), and obese (≥95th percentile)[29], but overweight and obese combined into ≥85th percentile. WC, T-SFT, and BF% were categorized as <5th, 5th-84th, and ≥85th percentiles, while M-SFT was categorized into <3rd, 10th-74th, and ≥75th percentiles.

Determination of physical activity and sedentary behavior

Participants' physical activity and sedentary time were objectively assessed using ActiGraph wGT3x-BT triaxial accelerometers (ActiGraph LLC, Pensacola, FL, USA). Children and adolescents were asked to wear the ActiGraph wGT3x-BT for seven consecutive days and were also instructed to wear an accelerometer attached to an elastic belt on the right hip. Participants and their parents were informed that the accelerometer should not be removed except for bathing and swimming. However, participants who did not want to wear the accelerometer during sleep were allowed to remove it. The ActiGraph wGT3X-BT was set to collect raw acceleration data at 30 Hz using ActiLife software (version 6.13.3).

Accelerometer data were analyzed using 15-second epochs. A valid day (wear time) was defined as ≥480 min-day-1 (8 h-day^{-1}). Accelerometer data from children and adolescents that included at least three valid weekdays and one valid weekend day were eligible for inclusion in the study.[30] Non-wear time was defined as a minimum of 60 consecutive minutes of zero counts, allowing for 2 minutes of counts between 0 and 100.[31] The cut-off points of Evenson et al.[32] were chosen to define sedentary time as <100 counts per minute (cpm), light physical activity as 101–2295 cpm, moderate physical activity as 2296–4011 cpm, and vigorous physical activity as ≥4012 cpm. As a result of data processing, sedentary time per day, light-intensity physical activity, and moderate-to-vigorous intensity physical activity were obtained for this study.

Statistical analyses

Results are presented as percentages, counts, and means ± standard deviations. Normality was assessed using skewness and kurtosis tests, and variance equality was evaluated with Levene's test. According to WHO guidelines, adolescents are defined as individuals aged 10-19 years.[33] Therefore, participants aged

6-9 years were categorized as children and those aged 10-17 years as adolescents. An independent-sample t-test was used to compare sedentary time, light-intensity physical activity, and moderate-to-vigorous intensity physical activity durations between age groups for both genders, following validation of normality and homogeneity assumptions. The significance level was set at p<0.05. Effect sizes were calculated using Cohen's d. Effect sizes (Cohen's d) are classified as small (d = 0.2), medium (d = 0.5), and large (d ≥ 0.8).[34] The missing data for anthropometric variables (26 participants) is attributable to those who did not participate in the anthropometric measurements among the 759 participants wearing accelerometers. For children and adolescents aged 5-17, a daily 60-minute moderate-to-vigorous intensity physical activity is recommended.[1] Participants were classified into two groups: those who met the 60-minute moderate-to-vigorous intensity physical activity guideline (active) and those who did not (inactive). A chi-square test was used to compare the percentiles of anthropometric variables between those meeting and not meeting the moderate-to-vigorous intensity physical activity guideline for both genders.

Results

Participant characteristics, including age, the percentiles of anthropometric variables, sedentary time, and physical activity, are presented in Table I. In addition, the comparison of sedentary time and physical activity levels between children and adolescents (different age groups) is presented in Fig. 1 for both genders. The comparison of anthropometric variables' percentiles according to whether or not they meet the physical activity recommendation in both boys and girls is shown in Tables II and III, respectively.

There were statistical differences in sedentary time (*p*=0.001; Cohen's *d*=0.99) and light-intensity physical activity (*p*=0.001; Cohen's *d*=0.13) between children in the 6-9 age group and adolescents in the 10-17 age group in boys (Fig. 1). The children's group had a significantly lower sedentary time than the adolescents for both genders, while they had a significantly higher light-intensity physical activity than adolescents (Fig. 1). No significant differences in moderate-to-vigorous intensity physical activity were found between children and adolescent boys. There were significant differences between children and adolescents in sedentary time (*p*=0.001; Cohen's *d*=0.85), light-intensity physical activity (*p*=0.001; Cohen's *d*=0.15), and moderate-to-vigorous intensity physical activity (*p*=0.001; Cohen's *d*=0.36) for girls (Fig. 1). Children had a significantly lower sedentary time and a higher level of light-intensity physical activity and moderate-to-vigorous physical activity than adolescents (Fig. 1).

Chi-square analysis showed that boys aged 6-9 years who did less than 60 minutes of moderate-to-vigorous intensity physical activity had a higher percentage of ≥85th percentiles for T-SFT and BF% than those who did 60 minutes or more, whereas those who did 60 minutes or more of moderate-to-vigorous intensity physical activity had a higher percentage of <5th and 5th-84th percentiles for T-SFT and BF% than those who did less than 60 minutes of moderate-to-vigorous intensity physical activity, (*p*<0.05, Table II). Conversely, the difference was insignificant for BMI, WC, and M-SFT percentiles. Among boys aged 10-17 years, those who did less than 60 minutes of moderate-to-vigorous intensity physical activity had a higher percentage of ≥85th percentile for BMI, T-SFT, M-SFT, and BF% than those who did 60 minutes or more, while those who did 60 minutes or more had a higher percentage of <5th and 5th-84th percentiles for BMI, T-SFT, M-SFT, and BF% than those who did less than 60 minutes of moderate-to-vigorous intensity physical activity (*p*<0.05, Table II).

Girls aged 6-9 years who did less than 60 minutes of moderate-to-vigorous intensity physical activity had a higher percentage of 5th-84th and ≥85th percentiles for BF% than

Table I. Descriptive characteristics of the participants.

Variables	Boys				Girls			
	Children (age 6-9)		Adolescents (age 10-17)		Children (age 6-9)		Adolescents (age 10-17)	
	n	Mean±SD	n	Mean±SD	n	Mean±SD	n	Mean±SD
Height (cm)	122	131.44±8.29	213	163.06±13.99	114	130.66±7.89	266	155.86±9.24
Body weight (kg)	124	30.70±9.24	218	55.69±16.48	115	28.74±6.72	274	50.19±11.75
Age (year)	128	8.32±1.02	230	13.84±2.28	119	8.31±1.05	282	13.90±2.27
BMI percentiles								
<5th	11	13.58±0,59	13	14.33±1.94	15	13.19±0.81	31	15.35±1.64
5th-84th	93	16.88±2.20	174	20.31±2.94	87	16.71±1.87	227	20.88±2.90
≥85th	17	24.12±4.56	22	28.21±3.56	10	22.34±1.94	6	30.26±3.95
WC percentiles								
<5th	19	49.46±2.68	29	58.04±4.98	30	49.01±3.01	110	59.40±4.70
5th-84th	103	59.54±6.92	184	70.80±7.09	84	57.86±5.28	159	68.29±6.46
≥85th	3	74.07±4.60	6	93.43±5.93	3	74.52±9.69	2	95.53±4.00
T-SFT percentiles								
<5th	6	4.58±0.77	7	4.63±0.84	3	5.63±0.55	7	6.74±0.54
5th-84th	70	9.16±2.26	146	9.62±2.96	66	10.94±2.58	196	14.68±3.87
≥85th	49	19.54±4.62	66	23.17±4.71	47	19.87±4.19	69	25.62±4.03
M-SFT percentiles								
<3rd	10	4.60±0.50	24	5.52±1.93	7	5.46±0.56	19	7.20±1.01
10th-74th	72	8.61±2.15	126	9.73±4.22	62	10.03±2.04	155	13.79±3.37
≥75th	43	19.85±4.57	69	23.82±5.59	45	18.24±4.90	97	24.64±4.16
BF% percentiles								
<5th	58	5.43±3.21	26	8.99±1.32	40	5.64±2.45	0	0±0
5th-84th	39	17.47±3.58	116	14.86±3.30	51	19.05±3.62	108	18.91±3.14
≥85th	28	32.74±5.55	77	34.40±7.35	24	30.69±5.42	163	30.90±5.85
Sedentary time (min/day)	128	594.91±178.91	230	784.08±202.77	119	636.45±184.47	282	801.23±202.15
LPA (min/day)	128	283.69±51.83	230	215.92±52.92	119	288.95±58.11	282	208.09±51.88
MVPA (min/day)	128	63.58±20.85	230	65.43±25.14	119	48.16±17.02	282	41.91±18.18
Wear time (min/day)	128	941.25±199.47	230	1061.68±208.91	119	974.45±209.15	282	1045.97±218.23

BF%, body fat percentage; BMI, body mass index; LPA, light-intensity physical activity; M-SFT, medial-calf skinfold thickness; MVPA, moderate-to-vigorous intensity physical activity; SD, standard deviation; T-SFT, triceps skinfold thickness; WC, waist circumference.

those who did 60 minutes or more. Those who did 60 minutes or more had a higher percentage of <5th percentile for BF% than those who did less than 60 minutes of moderate-to-vigorous intensity physical activity (p<0.05, Table III). Conversely, the difference was insignificant for BMI, WC, T-SFT, and M-SFT percentiles. Girls aged 10-17 years who did less than 60 minutes of moderate-to-vigorous intensity physical activity had a lower percentage of <5th and ≥85th percentiles for BMI than those who did 60 minutes or more, while those who did 60 minutes or more had a lower percentage of 5th-84th percentiles for BMI than those who did less than 60 minutes of moderate-to-vigorous intensity physical activity (p<0.05, Table III). Those who did less than 60 minutes of moderate-to-vigorous intensity physical activity had a higher percentage of ≥85th percentile for M-SFT and BF% than those who did 60 minutes or more. Additionally, those who did 60 minutes or more had a higher percentage of <5th (except

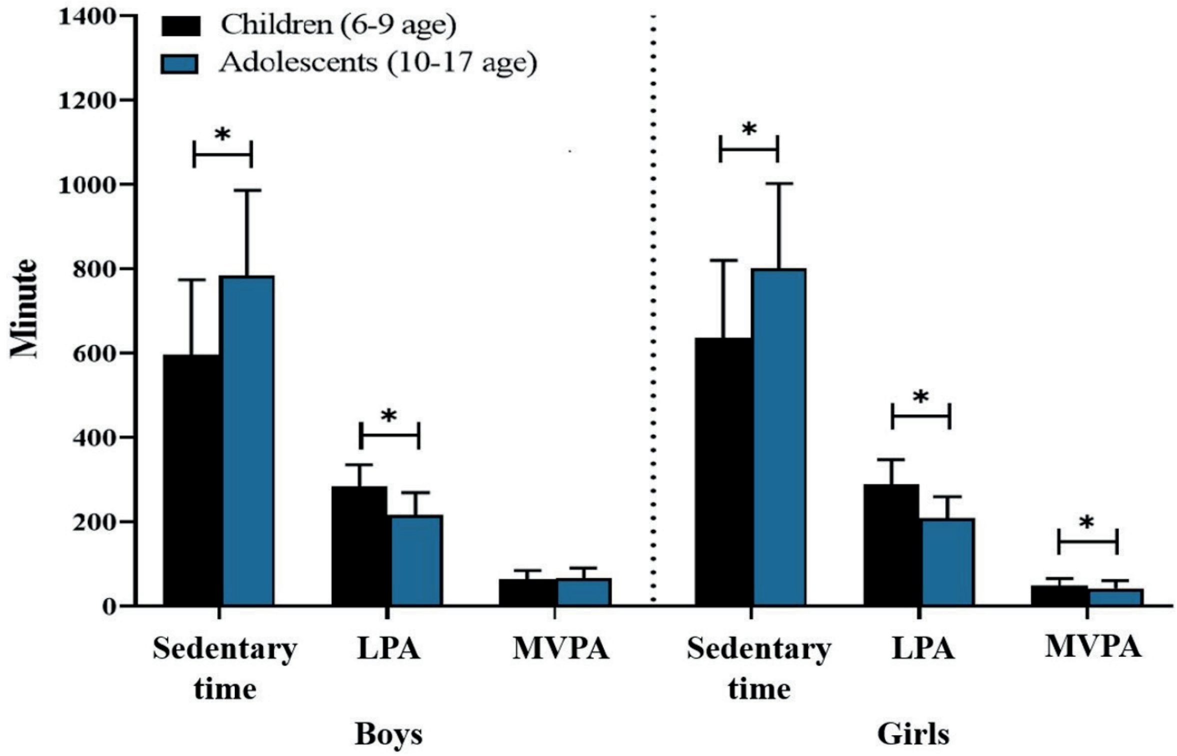

Fig. 1. The comparison of sedentary time and physical activity levels between children and adolescents in boys (*n=358*) and girls (*n=401*).

Sedentary time, light-intensity physical activity (LPA), and moderate-to-vigorous intensity physical activity (MVPA) values for boys and girls with different age groups.
*p<0.0.5

M-SFT) and 5th-84th percentiles for M-SFT and BF% than those who did less than 60 minutes of moderate-to-vigorous intensity physical activity, but the difference was insignificant for WC and T-SFT ($p<0.05$, Table III).

Discussion

The present study investigated the difference in sedentary time and physical activity levels between the age groups of children and adolescents and the difference in the percentiles of the anthropometric variables between those who met and those who did not meet the physical activity recommendation of the WHO for children and adolescents in both genders. The present study found that adolescents had higher sedentary time than children among boys, while light-intensity physical activity was lower. Among girls, sedentary time was higher in adolescents, but both light-intensity physical activity and moderate-to-vigorous intensity physical activity were higher in children. Physical activity generally decreases from childhood to adolescence, while sedentary time increases in these transition periods.[16] A systematic review by Pearson et al.[35] reported a 10-20 minute daily increase in sedentary time during the transition from primary/middle to secondary/high school in both genders. Studies have also shown an increase in sedentary time with age.[36-38] A study from the International Children's Accelerometer Database found a 4.2% decrease in total physical activity with age, mainly due to decreased light-intensity physical activity.[37] These studies are consistent with our study, which found higher sedentary time but lower light-intensity physical activity in adolescents than in children. Additionally, the average moderate-to-vigorous intensity

Table II. Percentiles of anthropometric variables according to meeting physical activity recommendations of the World Health Organization (≥ 60 min of MVPA per day) in boys.

	Variables	< 60 min of MVPA per day (n=56)		≥ 60 min of MVPA per day (n=69)		χ2	p
		n	%	n	%		
Children (age 6-9) (n=125)	BMI percentile						
	<5th	5	9.1	6	9.1		
	5th-84th	42	76.4	51	77.3	0.021	0.990
	≥85th	8	14.5	9	13.6		
	WC percentiles						
	<5th	9	16.1	10	14.5		
	5th-84th	44	78.6	59	85.5	3.535	0.167
	≥85th	3	5.4	0	0.0		
	T-SFT percentiles						
	<5th	1	1.8	5	7.2		
	5th-84th	26	46.4	44	63.8	7.424	0.021
	≥85th	29	51.8	20	29.0		
	M-SFT percentiles						
	<3rd	2	3.6	8	11.6		
	10th-74th	32	57.1	40	58.0	3.089	0.202
	≥75th	22	39.3	21	30.4		
	BF% percentiles						
	<5th	21	37.5	37	53.6		
	5th-84th	17	30.4	22	31.9	6.054	0.048
	≥85th	18	32.1	10	14.5		
	Variables	< 60 min of MVPA per day (n=105)		≥ 60 min of MVPA per day (n=114)		χ2	p
		n	%	n	%		
Adolescents (age 10-17) (n=219)	BMI percentiles						
	<5th	7	6.9	6	5.6		
	5th-84th	77	76.2	97	89.8	8.697	0.013
	≥85th	17	16.8	5	4.6		
	WC percentiles						
	<5th	13	12.4	16	14.0		
	5th-84th	87	82.9	97	85.1	2.985	0.228
	≥85th	5	4.8	1	0.9		
	T-SFT percentiles						
	<5th	1	1	6	5.3		
	5th-84th	61	58.1	85	74.6	13.056	0.001
	≥85th	43	41.0	23	20.2		
	M-SFT percentiles						
	<3rd	5	4.8	19	16.7		
	10th-74th	56	53.3	70	61.4	14.609	0.001
	≥75th	44	41.9	25	21.9		
	BF% percentiles						
	<5th	8	7.6	18	15.8		
	5th-84th	47	44.8	69	60.5	14.543	0.001
	≥85th	50	47.6	27	23.7		

BF%, body fat percentage; BMI, body mass index; M-SFT, medial-calf skinfold thickness; MVPA, moderate-to-vigorous intensity physical activity; SD, standard deviation; T-SFT, triceps skinfold thickness; WC, waist circumference.

Table III. Percentiles of anthropometric variables according to meeting physical activity recommendations of the World Health Organization (≥ 60 min of MVPA per day) in girls..

	Variables	< 60 min of MVPA per day (n=94)		≥ 60 min of MVPA per day (n=23)		χ2	p
		n	%	n	%		
Children (age 6-9) (n=117)	BMI percentile						
	<5th	13	14.3	2	9.5		
	5th-84th	70	76.9	17	81.0	0.335	0.846
	≥85th	8	8.8	2	9.5		
	WC percentiles						
	<5th	23	24.5	7	30.4		
	5th-84th	69	73.4	15	65.2	1.343	0.483
	≥85th	2	2.1	1	4.3		
	T-SFT percentiles						
	<5th	3	3.2	0	0.0		
	5th-84th	53	57.0	13	56.5	0.805	0.669
	≥85th	37	39.8	10	43.5		
	M-SFT percentiles						
	<3rd	4	4.3	3	13.6		
	10th-74th	53	57.6	9	40.9	3.672	0.132
	≥75th	35	38.0	10	45.5		
	BF% percentiles						
	<5th	27	29.3	13	56.5		
	5th-84th	45	48.9	6	26.1	5.893	0.049
	≥85th	20	21.7	4	17.4		

	Variables	< 60 min of MVPA per day (n=229)		≥ 60 min of MVPA per day (n=43)		χ2	p
		n	%	n	%		
Adolescents (age 10-17) (n=272)	BMI percentiles						
	<5th	20	9.0	11	26.8		
	5th-84th	198	88.8	29	70.7	10.728	0.005
	≥85th	5	2.2	1	2.4		
	WC percentiles						
	<5th	92	40.4	18	41.9		
	5th-84th	134	58.8	25	58.1	0.400	0.819
	≥85th	2	0.9	0	0.0		
	T-SFT percentiles						
	<5th	5	2.2	2	4.7		
	5th-84th	162	70.7	34	79.1	3.167	0.193
	≥85th	62	27.1	7	16.3		
	M-SFT percentiles						
	<3rd	14	6.1	5	11.6		
	10th-74th	127	55.7	28	65.1	4.341	0.047
	≥75th	87	38.2	10	23.3		
	BF% percentiles						
	<5th	0	0.0	0	0.0		
	5th-84th	81	35.5	27	62.8	11.219	0.001
	≥85th	147	64.5	16	37.2		

BF%, body fat percentage; BMI, body mass index; M-SFT, medial-calf skinfold thickness; MVPA, moderate-to-vigorous intensity physical activity; SD, standard deviation; T-SFT, triceps skinfold thickness; WC, waist circumference.

of physical activity decreased in girls by 41%, compared to 7% in boys.[19] Several studies have reported a decline in moderate-to-vigorous intensity physical activity during early adolescence, particularly in girls.[39,40] Farooq et al.[4] revealed that annual moderate-to-vigorous intensity physical activity decreased from age 6 in girls and 9 in boys. The annual decline in moderate-to-vigorous intensity physical activity from age 9 was 7.8% for boys and 10.2% for girls, with moderate-to-vigorous intensity physical activity generally decreasing with age in both genders.[4] However, in our study, moderate-to-vigorous intensity physical activity did not significantly decrease in boys aged 11-17 compared to ages 6-9. Early maturation, which is associated with increased height, body weight, and lean mass in boys, indicates a favorable physical structure, especially in types of physical activity that require speed, strength, and power.[41] Thus, the favorable physical structure may lead to an increase in moderate-to-vigorous intensity physical activity during early maturation.[41] Considering that those with early maturation in the present study are in the adolescent age groups, this may explain why moderate-to-vigorous intensity physical activity was not significantly higher in children, as moderate-to-vigorous intensity physical activity time may increase in adolescents.

Another finding of the present study was that the percentage of boys aged 6-9 years who were physically active were lower in the upper percentiles for BF% and T-SFT than those who were not. The percentage of boys aged 10-17 years who were physically inactive were higher in the upper percentiles for BMI, T-SFT, M-SFT, and BF% than in those who were. Girls aged 10-17 years who were physically inactive were higher in the upper percentiles of M-SFT and BF%, but they were not in the upper percentiles of BMI. A study by Mateo-Orcajada et al.[42] found that regular physical activity among adolescents resulted in lower BF%, fat mass, and fat mass index compared to physically inactive individuals. Other studies also provide evidence that SFT was higher in adolescents who engaged in regular physical activity.[43,44] Although the current study is consistent with the findings of these studies, it differs from them in that participants were divided into active or inactive groups according to WHO recommendations and physical activity was measured objectively.

Füssenich et al.[14] found that children meeting the physical activity recommendation of the WHO had a lower BF%. Chaput et al.[45] reported that children not meeting the physical activity guidelines were more likely to be overweight or obese. Studies indicate that BMI decreases as moderate-to-vigorous intensity physical activity increases in both boys and girls.[45-47] Higher moderate-to-vigorous intensity physical activity was associated with lower BMI and WC Z-scores at the 10th percentiles.[48] Thus, reducing childhood obesity prevalence could be achieved by shifting the upper percentiles of BMI and WC distributions to lower values.[48] These findings align with our results; however, in the present study, the percentage of adolescents meeting the physical activity recommendations was lower in the upper BMI percentiles among girls. This may be attributed to the limited sample size in these higher percentiles. A cross-sectional study of 225 children aged 7.9-11.1 years showed that moderate-to-vigorous intensity physical activity was not associated with BF% in Swedish children.[49] A number of studies have shown that physical activity was not associated with WC or BMI in both genders in children and adolescents.[5,50] Thus, the inconsistent findings suggest that more research is needed to determine the role of moderate-to-vigorous intensity physical activity on anthropometrics such as adiposity and BMI.[51]

A notable finding in the present study was that significant differences were found between the physically active and inactive groups in more anthropometric variables in adolescents of both genders compared with children. A United Nations large sample study found that the most statistically significant changes in adiposity, such as BMI and fat mass, occurred in adolescents aged 12-15 years.[52] Regular physical activity may be a critical factor in reducing obesity in late childhood and early adolescence, when physical activity declines significantly and obesity incidence is high.[53] Therefore, the role of physical activity in the significant changes in body composition that occur during adolescence may be more pronounced than in childhood. This may explain the difference between the active and inactive groups in more anthropometric variables in adolescents compared to children. Furthermore, in the present study, sedentary time was statistically lower in children than in adolescents for both girls and boys. In this respect, children in the active and inactive groups may have had a low daily sedentary time, which may have limited the role of physical activity. Limiting the role of physical activity could be another explanation for the difference in fewer anthropometric variables between the active and inactive groups in children.

The strengths of this study include being the first to objectively measure sedentary time and physical activity using accelerometers, with a large sample size representing 11 of the 12 regions of Türkiye. Accordingly, the analysis of physical activity and sedentary time of children from regions with different geographical and cultural characteristics is also an important strength of the study. As there is a limited number of health-related studies on light-intensity physical activity in the literature, the investigation of light-intensity physical activity is another strength of this study. The study also has several limitations. The anthropometric variables may have been influenced by nutritional status being potentially confounding factors, as sedentary time and physical activity may be associated with energy-inducing foods such as junk food. Another of the study's limitations is that although this study is a large study representing 11 regions of Türkiye, the number of participants for children and adolescents in the group 85th percentile or above is relatively low. In addition, the SFT measurements could have included more body sites. Additionally, another drawback is the lack of biological maturation determined by the Tanner stage. Biological maturation may significantly influence anthropometric variables associated with physical activity, suggesting it is an important confounding factor. Other limitations of the study include that the sample distributions of active and inactive children and adolescents were not close, especially for girls. Recent global data show that the majority (81%) of boys and girls aged 11-17 years do not meet physical activity recommendations. We believe that the higher number of participants not meeting physical activity recommendations in our sample is due to the high prevalence of inactivity worldwide.

In conclusion, our study revealed that both boys and girls had lower sedentary time than adolescents, while children had higher levels of light-intensity physical activity. There was no difference in moderate-to-vigorous intensity physical activity between children and adolescents in boys, but children had higher moderate-to-vigorous intensity physical activity than adolescents in girls. Children who met the physical activity recommendation were involved in lower percentiles for T-SFT and BF% (only BF% in girls) than those who did not. The study found that adolescents who met the physical activity recommendation were in lower percentiles of anthropometric variables than those who did not, highlighting the role of meeting physical activity recommendations in reducing the risk of obesity, especially in adolescents compared with children.

Acknowledgments

We would like to acknowledge the measurement team involved in the project measurements, the administrative team of schools, and the families who consented to their children's participation in the present study.

Ethical approval

This study was approved by the Non-Interventional Clinical Research Ethics Board of Hacettepe University (date: 16.07.2019, number: GO 19/713).

Author contribution

The authors confirm contribution to the paper as follows: Study conception and design: ND, AK, EC, PA, NK, MMC, EK, GD, SK, and ENÖ; data collection: ND, AK, EC, PA, NK, and MMC; analysis and interpretation of results: ND, AK, EC, EK; draft manuscript preparation: ND, AK. All authors reviewed the results and approved the final version of the article.

Source of funding

The authors declare that the study is funded by the Scientific and Technological Research Council of Türkiye (grant number: SBAG-120S408) and Hacettepe University Scientific Research Projects Coordination Unit (grant number: THD-2022-20266).

Conflict of interest

The authors declare that there is no conflict of interest.

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