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Physical activity and physical fitness in obese, overweight, and normal-weight children

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Background/aim: The aim was to assess the differences between physical activity and physical fitness in obese, overweight, and normal-weight children.

Materials and methods: The cross-sectional study was accomplished using cluster sampling method at 3 Lithuanian schools. An analysis of anthropometric data for 532 Lithuanian children was performed. Height, weight, waist and hip circumferences, and skinfold thickness were measured. Body mass index, waist-to-hip ratio, and body fat percentage were calculated. The Youth Physical Activity Questionnaire and a 6-min walk test (6MWT) were administered to evaluate physical activity and physical fitness. Maximal oxygen consumption was calculated to assess the children's aerobic capacity. Correlations among anthropometric data, 6MWT-walked distance, and moderate-vigorous physical activity duration were analyzed.

Results: The study showed that 20.1% of the studied children were obese or overweight. They engaged in moderate-to-vigorous physical activity 22.4 min less per day and walked 50.9 m less on average during a 6-min test than normal-weight children. Physical fitness parameters correlated with daily moderate-vigorous physical activity duration and with most of the children's anthropometric parameters.

Conclusion: Obese and overweight children were less physically active and had lower physical fitness than normal-weight children. The findings underline the need for interventions to increase physical activity and improve fitness in obese and overweight children.

Key words: Physical activity, physical fitness, obesity, overweight, children

1. Introduction

The prevalence of obesity among adults has been slightly increasing or has showed stabilization in the most European countries over the last 15 years (1). Among European children and adolescents, a decrease, a leveling off, or a stabilization in the prevalence of obesity was observed in nearly all countries (1–4). However, in the United States, rates of severe childhood obesity have tripled in the last 25 years (5).

Obesity is strongly associated with major health risk factors; obesity increases risk for diabetes, asthma, arthritis, hypertension, adverse levels of lipids, and reductions in life expectancy (6–10). Overweight children and adolescents have an increased risk of becoming overweight as adults (7,11).

Obesity is an excess of adipose tissue that results from a combination of genetic predisposition, environmental influences, and behavioral components (12). Physical activity plays an important role in obesity control because it alters the balance between caloric intake and expenditure. Studies show that the most important role in obesity control is played by physical activity: moderate-to-vigorous intensity physical activity and reduction of screen-focused sedentary time. Physical activity is positively associated with motor skills and aerobic fitness in children. Through aerobic fitness, physical activity is positively linked with the risk reduction of chronic diseases and metabolic syndrome (13–15). Children who are overweight but participate in physical activities that positively impact physical fitness may have fewer metabolic syndrome risk factors compared to children who are overweight but do not engage in activities that improve physical fitness (15). Studies show that low amounts of physical activity, high total body fat, abdominal fat, and body fat distribution are related to higher composite risk factor scores for cardiovascular disease in children (16,17). Regular moderate-to-vigorous physical activity can lead to improvements in cardiorespiratory fitness at any age (18).

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The relationship between physical activity and aerobic fitness in healthy children has been examined in a number of earlier studies. It is recommended to use a 6-min walk test (6MWT) and to calculate maximal oxygen consumption (VO_2max) as markers for aerobic fitness evaluation in obese children (19). Most studies have shown a weak-to-moderate correlation between physical activity and fitness in obese and overweight children; however, further prospective studies are necessary for determining the interrelationships among physical activity, physical fitness, and being overweight (20,21).

Based on the results of earlier studies, we raised the hypothesis that obese and overweight children are less physically active and have lower physical fitness than normal-weight children have. Therefore, the aim of this study was to assess the differences between physical activity and physical fitness in obese, overweight, and normal-weight children.

2. Materials and methods

2.1. Study design and population

The cross-sectional study was performed using a cluster sampling method at 3 Lithuanian schools. All children in grades 5 to 7 were invited to participate. The participation rate was 84.7%. The study population consisted of 532 children, aged from 11 to 14 years (mean: 12.99 ± 0.96).

The study was conducted with the approval of the Lithuanian Bioethics Committee (Protocol No. 1, 6/4/2003). Informed consent was obtained in written form from the parents of each participating child.

2.2. Anthropometric measurements

2.2.1. Body mass index (BMI)

Body height was measured to the nearest 0.5 cm according to the standard procedure, with the children standing upright without shoes, with hips and shoulders perpendicular to the central axis, feet and knees together, and the head in the Frankfurt plane. Body weight was measured to the nearest 0.5 kg using a doctor's scale. BMI was calculated as body weight in kilograms divided by body height in square meters. The studied children were defined as obese, overweight, normal-weight, and underweight according to the World Health Organization (WHO) child growth characteristics for age, sex, and BMI (22). Underweight children were excluded from the study because of the insufficient sample size.

2.2.2. Waist-to-hip ratio (WHR)

Waist circumference (WC) was measured to the nearest 0.5 cm at the midpoint between the lower border of the rib cage and the iliac crest at the end of a normal expiration. Hip circumference (HC) was measured to the nearest 0.5 cm at the widest part of the hip from the greater trochanter. WHR was calculated by dividing WC by HC (23).

2.2.3. Body fat (BF%)

Skinfold thicknesses were measured to the nearest 0.5 mm using a Saehan caliper. Tricep (midway between the olecranon process and the acromion process on the posterior aspect of the arm) and subscapular (the inferior angle of the scapula) skinfold thicknesses were measured by highly trained technicians following recommended protocols (24). All measurements were taken on the right side of the body. Body fat percentages were calculated with the following formulas (25):

BF% for children with tricep and subscapular skinfolds of <35 mm:

Boys = 1.21 (sum of 2 skinfolds) – 0.008 (sum of 2 skinfolds)^2 – 3.4

Girls = 1.33 (sum of 2 skinfolds) – 0.013 (sum of 2 skinfolds)^2 – 2.5

BF% for children with triceps and subscapular skinfolds of >35 mm:

Boys = 0.783 (sum of 2 skinfolds) + 1.6

Girls = 0.546 (sum of 2 skinfolds) + 9.7

2.3. Youth Physical Activity Questionnaire (YPAQ)

The YPAQ (26) contains a list of 47 different activities for which participants are requested to self-report the frequency and duration of each activity for both weekdays and weekend days over a 7-day period. The YPAQ assesses mode, frequency, and duration of physical activity and sedentary activities throughout all domains, including school time and leisure time.

In the study, the total duration of time spent on moderate-to-vigorous intensity physical activity (MVPA) and screen-sedentary time (SST) were used. MET (metabolic equivalent) minutes of physical activity were calculated as duration × frequency × MET intensity (27).

The questionnaire was translated into the Lithuanian language. Back translation was performed, compared, and discussed. Cultural adaptation was performed, and the final version of the questionnaire was applied and tested during the pilot study.

2.4. Six-minute walk test (6MWT)

6MWTs were conducted using a lap 54 m in length on flat, hard ground, according to the ATS guidelines (28). Instructions were given to all participating children before conducting the walk test. The children were asked to walk each measured lap at their best pace but not to run or race. The tests were conducted in small groups (6–8 children in each group).

Aerobic capacity was assessed according to 6MWT results and BMI by means of the following formula (19):

VO_2max (mL kg^{-1} min^{-1}) = 26.9 + 0.014 × 6MWT distance (m) – 0.38 × BMI (kg/m^2)

2.5. Statistical analyses

Descriptive statistics are presented as absolute data numbers (n) and the mean with standard deviation

(SD). The Kolmogorov–Smirnov test was applied to check hypotheses for the regularity of distribution of the parameters. For comparisons of the quantitative variables of 2 independent groups, the parametric Student t-test and nonparametric Mann–Whitney test were applied. The Pearson correlation coefficient was used to estimate correlations. $P < 0.05$ was regarded as statistically significant. The data were analyzed with SPSS 20.0 for Windows.

3. Results

Anthropometric data showed that boys had a higher mean value of BMI in all age groups (19.9 ± 4.3) and mean value of WHR (0.79 ± 0.07) compared with girls, who had a mean value of BMI of 18.9 ± 3.5 (P = 0.049) and mean value of WHR of 0.75 ± 0.04 (P < 0.001). The comparison of body fat in groups by sex revealed that girls had a higher percentage of body fat (27.5 ± 9.2%) than boys (26.3 ± 12.6%), but this difference was not statistically significant (P = 0.304). Anthropometric data for the studied children are presented in Table 1.

According to WHO child growth characteristics for age, sex, and BMI, the studied children were classified as obese (12.2%), overweight (7.9%), normal-weight (73.5%), or underweight (6.4%) (Table 2). More boys (25.4%) than girls (15.6%) were obese or overweight (P = 0.026).

Basic characteristics for comparison of physical activity and physical fitness are shown in Table 3. Physical activity parameters (MVPA duration and daily energy expenditure by MET-min/day) were statistically significant between children with different body mass indexes: obese and overweight children engaged in MVPA 22.4 min per day less (P = 0.018) and expended 126.3 MET-min/day less energy (P = 0.001) than normal-weight children. Surprisingly, daily SST was slightly higher in normal-weight children (114.4 min/day) compared with obese and overweight children (105.3 min/day), but this was not a statistically significant difference (P = 0.344).

Differences in physical fitness parameters (6MWT distance, VO_2max) were highly statistically significant between children with different body mass indexes. Obese and overweight children walked 50.9 m less on

Table 1. Anthropometric data of children according to sex and age.

	Girls (n = 288)					Boys (n = 244)					P-value
	11 years Mean (SD)	12 years Mean (SD)	13 years Mean (SD)	14 years Mean (SD)	Total Mean (SD)	11 years Mean (SD)	12 years Mean (SD)	13 years Mean (SD)	14 years Mean (SD)	Total Mean (SD)	
Weight (kg)	40.4 (8.9)	45.2 (12.4)	47.6 (8.9)	51.1 (10.5)	47.7 (10.9)	42.8 (9.6)	43.7 (13.9)	49.7 (12.7)	55.1 (14.3)	49.9 (14.3)	P = 0.073
Height (cm)	150.2 (7.8)	152.8 (5.8)	156.6 (7.9)	162.3 (7.5)	157.4 (8.6)	152.0 (3.6)	150.7 (7.4)	157.4 (8.1)	163.3 (8.1)	157.6 (9.3)	P = 0.828
BMI (kg/m^2)	17.7 (2.5)	18.9 (4.3)	19.3 (2.7)	19.2 (3.1)	18.9 (3.5)	18.9 (4.2)	18.6 (4.3)	19.9 (3.4)	21.0 (4.9)	19.9 (4.3)	P = 0.049*
WC (cm)	60.4 (4.9)	64.2 (9.4)	65.1 (6.6)	65.7 (6.7)	64.7 (7.3)	64.4 (10.8)	66.9 (11.5)	67.5 (9.2)	70.4 (10.2)	68.3 (10.4)	P < 0.001*
HC (cm)	81.7 (5.9)	83.4 (9.3)	85.7 (7.4)	88.8 (7.6)	86.0 (8.2)	82.1 (7.8)	81.9 (11.7)	86.4 (9.4)	89.0 (9.1)	86.0 (10.3)	P = 0.986
WHR	0.74 (0.02)	0.77 (0.05)	0.76 (0.04)	0.74 (0.05)	0.75 (0.04)	0.78 (0.05)	0.82 (0.11)	0.78 (0.04)	0.79 (0.05)	0.79 (0.07)	P < 0.001*
Tricep SFT (mm)	20.2 (7.2)	18.9 (8.5)	21.0 (7.5)	21.3 (6.9)	20.6 (7.5)	16.4 (5.8)	20.0 (7.1)	19.6 (7.5)	17.1 (9.1)	18.8 (7.9)	P = 0.016*
Subscapular SFT (mm)	14.1 (7.0)	16.0 (10.8)	16.9 (8.3)	16.5 (7.4)	16.2 (8.5)	12.1 (8.1)	15.3 (10.2)	16.9 (10.5)	15.2 (9.4)	15.7 (9.9)	P = 0.554
Body fat (%)	25.9 (8.2)	26.3(11.2)	28.1 (9.3)	28.0 (8.0)	27.5 (9.2)	22.0 (10.1)	26.9 (12.3)	27.8 (12.5)	24.8 (13.1)	26.3 (12.6)	P = 0.304

BMI: body mass index; WC: waist circumference; HC: hip circumference; WHR: waist-to-hip ratio; Triceps SFT: triceps skinfold thickness; Subscapular SFT: subscapular skinfold thickness. *P < 0.05.

Table 2. Weight status in children according to sex.

	Total (n = 532)	Girls (n = 288)	Boys (n = 244)	P-value
	n (%)	n (%)	n (%)	
Obese	65 (12.2%)	29 (10.1%)	36 (14.8%)	P = 0.026*
Overweight	42 (7.9%)	16 (5.6%)	26 (10.7%)	P = 0.026*
Normal-weight	391 (73.5%)	225 (78.1%)	166 (68.0%)	P = 0.026*
Underweight	34 (6.4%)	18 (6.3%)	16 (6.6%)	P = 0.026*

Classified according to WHO child growth characteristics (21). *P < 0.05.

Table 3. Parameters of physical activity (MVPA, SST, MET-min/day) and physical fitness (6MWT distance, VO_2max) in obese, overweight, and normal-weight children according to sex.

	Obese and overweight children				Normal-weight children				P-value
	n	Girls Mean (SD)	Boys Mean (SD)	Total Mean (SD)	n	Girls Mean (SD)	Boys Mean (SD)	Total Mean (SD)	
Parameters of physical activity:									
MVPA (min/day)	97	76.3 (46.6)	80.5 (49.4)	78.9 (48.0)	391	96.8 (83.3)	92.0 (49.8)	101.3 (99.1)	P = 0.018*
SST (min/day)	82	127.1 (92.1)	162.1 (106.1)	105.3 (72.9)	348	126.5 (92.3)	176.8 (121.3)	114.4 (98.3)	P = 0.344
MET-min/day	97	376.0 (228.6)	443.2 (225.6)	414.8 (227.9)	391	524.7 (516.6)	518.0 (287.2)	541.1 (561.8)	P = 0.001*
Parameters of physical fitness:									
6MWT distance (m)	65	599.0 (127.2)	577.4 (131.9)	582.2 (126.8)	237	588.1 (123.4)	714.0 (155.1)	633.1 (137.8)	P = 0.011*
VO_2max (mL kg^{-1} min^{-1})	62	26.1 (2.1)	25.8 (2.1)	26.1 (2.1)	227	28.4 (2.2)	30.2 (2.3)	29.1 (2.2)	P < 0.001*

MVPA: moderate-vigorous physical activity; SST: screen sedentary time; MET: metabolic equivalent; 6MWT: 6-min walk test; VO_2max: maximal oxygen consumption. *P < 0.05.

average during the 6MWT than normal-weight children (P = 0.011). Calculated VO_2max in obese and overweight children ranged from 21.6 to 30.8 mL kg^{-1} min^{-1} while in normal-weight children it ranged from 24.9 to 34.3 mL kg^{-1} min^{-1} during the 6MWT test. The 6MWT-walked distance (in meters) had a very strong positive statistically significant relationship (r = 0.867, P < 0.001) with calculated VO_2max in children.

The 6MWT-walked distance (m) correlated with most of the anthropometric parameters for the studied children. Moderately significant (P < 0.001) negative relationships with BF% and tricep and subscapular skinfold thickness were found. BMI and hip and waist circumferences showed weakly and very weakly significant (P < 0.001) negative relationships (Table 4), respectively. MVPA duration (min/day) had very weak relationships with 6MWT distance (m), calculated VO_2max, and anthropometric parameters of the children (r coefficient ranged from –0.106 to 0.187) (Table 5).

Table 4. The 6MWT distance (m) correlations with anthropometric parameters, VO_2max (mL kg^{-1} min^{-1}), and MVPA (min/day).

	6MWT distance (m)								
	n	Total		n	Girls		n	Boys	
		r	P-value		r	P-value		r	P-value
BMI	297	–0.245	P < 0.001*	172	–0.222	P = 0.003*	125	–0.320	P < 0.001*
WC (cm)	302	–0.184	P = 0.006*	173	–0.204	P = 0.007*	129	–0.243	P = 0.006*
HC (cm)	302	–0.257	P < 0.001*	173	–0.291	P < 0.001*	129	–0.228	P = 0.009*
Triceps SFT (mm)	296	–0.332	P < 0.001*	173	–0.135	P = 0.076	123	–0.434	P < 0.001*
Subscapular SFT (mm)	296	–0.321	P < 0.001*	173	–0.189	P = 0.013*	123	–0.420	P < 0.001*
Body fat (%)	296	–0.354	P < 0.001*	173	–0.172	P = 0.023*	123	–0.447	P < 0.001*
VO_2max (mL kg^{-1} min^{-1})	297	0.867	P < 0.001*	172	0.867	P < 0.001*	125	0.886	P < 0.001*
MVPA (min/day)	300	0.187	P < 0.001*	171	0.065	P = 0.396	129	0.270	P = 0.002*
SST (min/day)	302	0.044	P = 0.457	173	0.012	P = 0.873	129	–0.022	P = 0.811

6MWT: 6-min walk test; BMI: body mass index; WC: waist circumference; HC: hip circumference; Triceps SFT: triceps skinfold thickness; Subscapular SFT: subscapular skinfold thickness; VO_2max: maximal oxygen consumption; MVPA: moderate-vigorous physical activity. *P < 0.05.

Table 5. MVPA (min/day) correlations with anthropometric parameters, VO_2max (mL kg^{-1} min^{-1}), and 6MWT distance (m).

	MVPA (min/day)								
	n	Total		n	Girls		n	Boys	
		r	P-value		r	P-value		r	P-value
BMI	422	−0.106	P = 0.016*	233	−0.102	P = 0.121	189	−0.158	P = 0.029*
WC (cm)	411	−0.108	P = 0.071	227	−0.106	P = 0.110	184	−0.081	P = 0.276
HC (cm)	411	−0.168	P = 0.007*	227	−0.179	P = 0.007*	184	−0.133	P = 0.073
Triceps SFT (mm)	401	−0.117	P = 0.025*	227	−0.164	P = 0.014*	174	−0.168	P = 0.376
Subscapular SFT (mm)	401	−0.121	P = 0.169	227	−0.085	P = 0.202	174	−0.074	P = 0.332
Body fat (%)	401	−0.128	P = 0.067	227	−0.129	P = 0.053	174	−0.074	P = 0.330
VO_2max (mL kg^{-1} min^{-1})	295	0.181	P = 0.001*	170	0.100	P = 0.193	125	0.294	P = 0.001*
6MWT distance (m)	300	0.187	P < 0.001*	171	0.065	P = 0.396	129	0.270	P = 0.002*

MVPA: moderate-vigorous physical activity; BMI: body mass index; WC: waist circumference; HC: hip circumference; Triceps SFT: triceps skinfold thickness; Subscapular SFT: subscapular skinfold thickness; VO_2max: maximal oxygen consumption; 6MWT: 6-min walk test. *P < 0.05.

4. Discussion

Our study revealed that 20.1% of the children were obese and overweight, 73.5% were of normal weight, and 6.4% were underweight among the study population. There are few studies in which analysis of the prevalence of obesity and overweight in Lithuanian children was accomplished. A study conducted in 2003–2006 showed that the prevalence of obesity among preschool Lithuanian children was 0.8%–3.7% in boys and 0%–1.9% in girls; the prevalence of being overweight was 6.5%–12.4% in boys and 10.7%–18.2% in girls (29). The Health Behaviour in School-Aged Children study showed that the prevalence of being overweight and obese in Lithuanian teenagers aged 13–15 years old was 5%–10% in girls and 13%–16% in boys (30).

By 2010, more than 40% of children in the North American and Eastern Mediterranean WHO regions, 38% in Europe, 27% in the Western Pacific, and 22% in Southeast Asia are predicted to be overweight or obese (31). Gupta et al. (32) found that rapidly changing dietary practices and a sedentary lifestyle have recently led to an increasing prevalence of childhood obesity (5–19 years) in developing countries: 41.8% in Mexico, 22.1% in Brazil, 22.0% in India, and 19.3% in Argentina.

Studies conducted in Turkey are in compliance with our study and with the studies of Western countries. There is a constant increase in BMI values in Turkish children of both sexes, especially during the pubertal years (33). Therefore, weight-for-age values indicate an increase in obesity among Turkish children aged 6 to 18 years in recent years (34).

Our study showed that obese and overweight children spend 78.9 min/day in MVPA and expend 414.8 MET-min/day, while normal-weight children spend 101.3 min/day in MVPA and expend 541.1 MET-min/day. This shows that increased weight status is associated with lower MVPA duration, although most children meet the MVPA guidelines. The WHO (35) recommends that school-aged children and youth accumulate at least 60 min of moderate-to-vigorous intensity physical activity (MVPA) every day for health benefits.

Other studies also provide evidence that increased weight status is associated with lower MVPA duration. In preschoolers, the time spent in vigorous physical activity was strongly and independently associated with lower adiposity (36). Non-SST (NSST) for adolescents was associated with weight status (P = 0.003), with thinner adolescents generally accumulating more NSST. Normal-weight adolescents experienced 25 min/day more NSST than obese adolescents (37). Overweight 11-year-old children engaged in less physical activity of both moderate and vigorous intensity compared with their normal-weight peers. Both overweight and normal-weight children were less active on weekends than on weekdays (38).

An interesting finding from our study was that the daily SST was slightly higher in normal-weight children (114.4 min/day) compared with obese and overweight children (105.3 min/day). Collings et al. (36) also found that the time spent in sedentary and in low-to-moderate-intensity physical activity was unrelated to adiposity. However, these findings are in contrast with studies from Australia and the United States conducted with this age group of children. Maher et al. (39) found that in Australian children, being overweight and obese was more strongly associated with screen time than physical activity. A longitudinal study conducted in the United States by Mitchell et al. (40)

provided evidence that spending more time on objectively measured sedentary behavior was associated with greater increases in BMI during childhood. Importantly, these observed associations were independent of time spent in MVPA. Specifically, it was observed that spending more time in sedentary activities was associated with greater increases in BMI for ages 9 to 15 years at the 50th BMI percentile and above. This suggests that reducing sedentary behavior at the population level may be an effective public health strategy for reducing the prevalence of obesity in childhood.

A similar study of children and adolescents in Sweden showed that low levels of total physical activity and especially vigorous physical activity could play an important role in the development of overweight and excess central adiposity in children and adolescents, independently of a number of factors such as television viewing and birth weight (41). The authors of this study suppose that the association between television viewing and central fat deposition could be attenuated if enough vigorous physical activity is accumulated.

Authors from the United States found that higher moderate-to-vigorous physical activity was associated with lower fat mass. Sedentary time and frequency of breaks in sedentary time were not associated with fat mass (42). These results do not mean that sedentary time is unimportant. It is clear that sedentary time can displace time for physical activity. These results emphasize the fact that sedentary time should be replaced with time devoted to moderate-to-vigorous physical activity in order to prevent increasing fat mass and obesity in children and adolescents.

In the current study, the 6MWT showed that obese and overweight children have a lower physical fitness than normal-weight children. Obese and overweight children walked 582.2 m and had 26.1 mL kg^{-1} min^{-1} VO_2max on average during the 6MWT, while normal-weight children walked 633.1 m and had 29.1 mL kg^{-1} min^{-1} VO_2max on average during the same test. The 6MWT-walked distance (m) had a very strong positive significant relationship with calculated VO_2max and negative statistically significant correlations with most of the anthropometric parameters of children: BF%, tricep and subscapular skinfold thickness, BMI, and hip and waist circumferences. MVPA in boys was statistically significantly correlated with 6MWT distance and VO_2max. Studies showed that boys exhibit reliably higher values of aerobic fitness during puberty compared with girls (43). Moreover, in girls, a negative statistically significantly correlation was found between MVPA and tricep skinfold thickness, as well as between MVPA and HC. This difference may have occurred because girls have more body fat than boys before puberty (44), and girls are significantly fatter than boys at 10–14 years old (43).

Other studies have shown similar findings. A study of 8–13-year-old Chinese children showed a significantly lower level of cardiorespiratory fitness in overweight/obese children compared to those of normal weight (45). In addition, the authors found that initial cardiorespiratory fitness levels were a significant predictor of body weight gain. A European cross-sectional youth heart study generally showed a weak association between aerobic fitness and physical activity (20). However, the study also indicated that inactive children could achieve a notable increase in aerobic fitness by increasing their habitual level of physical activity. Research into Spanish children contributed to the recognition that an adequate level of fitness and physical activity during childhood leads to better health and oxidative status (46). According to Yosmaoğlu et al.'s study (47), the effect of home-based aerobic exercise programs to treat adolescent obesity was limited. In Turkey, preventive public health measures have started to be implemented to control the increase of obesity (48).

The study concluded that obese and overweight children are less physically active and have lower physical fitness than normal-weight children. These findings underline the need for interventions to increase physical activity and improve fitness in obese and overweight children.

The strength of the study was that an analysis of the association between physical activity and physical fitness (in obese, overweight, and normal-weight children) was accomplished. It could be used as evidence-based knowledge for promoting health-enhancing physical activity in children. Evidence supports the importance of physical activity, and our results revealed how physical activity interacts with physical fitness.

The main limitation of the study was that we did not analyze underweight children. However, they could be included in our future studies.

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