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Original Article

Peak expiratory flow, core performance and physical activity in normal-weight, overweight, and obese adolescents

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Highlights

- Few studies have explored the connections between pulmonary function, physical activity, and core performance in overweight and obese children and adolescents.
- To our knowledge, this is the first study to compare pulmonary function, physical activity, and core performance across normal-weight, overweight, and obese adolescents and to examine their interrelationships.
- This study revealed that both pulmonary function and core performance are linked to obesity, while pulmonary function and physical activity are correlated with being overweight.

Abstract. The objectives of this study were to (1) compare peak expiratory flow (PEF), physical activity (PA), and core performance among normal-weight, overweight, and obese adolescents and (2) explore the relationships between PEF, physical activity, core performance, and anthropometric measurements across these groups. Ninety adolescents aged 10–13 yr were categorized based on BMI: normal weight (n = 30, 5th to < 85th percentile, BMI-Z score –2 to < 1), overweight (n = 30, 85th to < 95th percentile, BMI-Z score 1 to < 2), and obese (n = 30, > 95th percentile, BMI-Z score > 2). PEF and percent-predicted values of PEF (PEF% pred) values were calculated. Waist and neck circumferences were measured. Physical activity levels were assessed using the Physical Activity Questionnaire for Older Children (PAQ-C), from which total and subscores were derived. Core performance was evaluated through modified push-up (MPU) and sit-up tests. The PEF% pred and PAQ-C scores showed no significant differences between groups ($p > 0.05$). However, MPU repetition rates were significantly lower in obese adolescents compared to overweight ($p = 0.019$) and normal-weight peers ($p < 0.001$). There was a significant correlation between PEF% pred and PAQ-C total scores ($p = 0.014$), as well as out-of-school subscores ($p = 0.039$) in overweight adolescents. Similarly, PEF% pred was linked to MPU repetitions in obese adolescents ($p = 0.029$). Obese adolescents exhibited decreased core performance relative to their overweight and normal-weight counterparts, which correlated with the PEF% pred. Physical activity was associated with PEF% pred exclusively in overweight adolescents.

Key words: obesity, core performance, peak expiratory flow, physical activity

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Introduction

The World Health Organization (WHO) defines obesity as abnormal or excessive fat accumulation that poses health risks. According to the WHO, 1.9 billion people globally are overweight, including 600 million who are obese and 41 million children under the age of five who are overweight or obese (1). Childhood obesity is a critical concern as it may lead to type 2 diabetes, hypertension, and cardiovascular, respiratory, and orthopedic disorders in adulthood, in addition to its increasing prevalence (1).

The primary cause of obesity and overweight is an imbalance between calories consumed and expended. Although physical inactivity is strongly linked with obesity in children and adolescents (2), recent studies have yielded mixed results (3). Moreover, obesity can directly impair respiratory health by increasing oxygen consumption and carbon dioxide production, reducing peak expiratory flow (PEF), and augmenting the mechanical work of breathing (4). Few studies have found that PEF values are significantly lower in obese children compared to their normal-weight peers (5, 6). Respiratory function is compromised in obese children due to decreased compliance of the chest wall and lungs and increased respiratory resistance (7). However, some researchers contend that only extreme obesity affects lung function and have reported conflicting findings (8).

The core of the body includes the abdominal muscles at the front, paraspinal and gluteal muscles at the back, pelvic floor muscles at the bottom, and the diaphragm at the top. The diaphragm, the largest respiratory muscle, plays a crucial role in core performance by managing intra-abdominal pressure (9). Studies have indicated that physical inactivity is negatively correlated with muscle strength and positively correlated with overweight and obesity among school-aged children (10). Obesity also diminishes skeletal muscle contraction and core muscle endurance (11). One study that assessed functional movement scores in normal-weight, overweight, and obese children found that none of the obese children achieved a full score on the trunk stability push-up and rotary stability tests, which are closely linked to core performance (12). It has also been reported that poorer functional movement, including in the core area, is associated with higher BMI and lower levels of physical activity (13). Despite the known contributions of core muscles to respiratory patterns and physical activity engagement, to our knowledge, no study has yet explored the relationship between core performance and respiratory function in obese or overweight children.

Current literature presents mixed results regarding the impact of obesity on respiratory function in adolescents. Additionally, the relationship between respiratory function, physical activity, and core performance is poorly understood, with most research focusing on adults. Given the rising prevalence of obesity among children and adolescents, a thorough examination of its consequences is crucial for secondary prevention. Therefore, the primary goal of our study was to compare PEF as a measure of respiratory function, along with physical activity and core performance, between normal-weight and overweight or obese adolescents. The secondary goal was to explore the relationship between PEF, physical activity, core performance, and anthropometric measurements across normal-weight, overweight, and obese adolescents.

Materials and Methods

This study was conducted from September to December 2022 at a local school. Adolescents aged 10–13 yr, classified as normal-weight, overweight, or obese according to their BMI-Z score and percentile values, were invited to participate. The university's ethics committee approved the study protocol, which adhered to the Declaration of Helsinki. Written informed consent was obtained from the parents and all participating adolescents (ethical board approval number: 2022/70–09, clinical trial registration number: NCT05470556).

The sample size was calculated using the G*Power 3.1 program, based on an R2 value of 0.699 and an effect size of 2.322, which were indicative of the peak BMI-Z score's influence on PEF as observed in obese children from a previous study (5). The study required a minimum of 20 adolescents per group to achieve 99% power with an alpha level of 0.05. To account for potential dropouts, the sample was increased by 50%, resulting in 30 participants per group (normal-weight, overweight, obese), totaling 90 participants. The study was completed with all 90 participants.

Participants were included if they were aged between 10 and 13 yr and fell into the normal-weight (5th to < 85th percentile, BMI-Z score –2 to < 1), overweight (85th to < 95th percentile, BMI-Z score 1 to < 2), or obese (> 95th percentile, BMI-Z score > 2) categories according to WHO standards. Exclusion criteria included a BMI percentile below the 5th percentile, a BMI-Z score ≤ –2, or a diagnosis of orthopedic, neurological, cardiac, or pulmonary diseases. Those unable to cooperate with the assessments or on medication other than vitamins were also excluded.

Demographic data were recorded. Peak expiratory flow, waist, and neck circumferences were measured, physical activity levels were assessed, and core performance was evaluated, all on the same day for each participant. Adolescents were instructed to rest for 15 min between performance-based assessments.

The date of birth, height, weight, and sex of all adolescents were entered into the WHO AnthroPlus program to calculate BMI-Z scores and percentile values. Waist and neck circumferences were assessed using anthropometric measurements. Waist circumference was measured in the standing position by determining the midpoint between the lowest rib and the iliac crest using a tape measure on the exposed waist area. Neck circumference was measured from the lower border of the laryngeal prominence with a tape measure (14).

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PEF is a crucial parameter of pulmonary function and serves as a clinical tool for managing and monitoring respiratory health. In this study, PEF was measured using a PEF meter (Mesilife, China) in the morning while the participant was standing. The PEF meter was set to zero; after taking a deep breath and exhaling forcefully, three measurements were taken, and the highest value was recorded as the PEF (L/min) (15). Peak expiratory flow was expressed as a percentage of predicted values based on age, sex, and height (PEF% pred = [(height in cm × 5) + 100]) (16).

Core performance was evaluated using the modified push-up (MPU) and sit-up tests. For the MPU, adolescents started on a mat in the prone position with knees and elbows flexed, then pushed their trunks backward to full elbow extension. In the sit-up test, adolescents lifted their trunks from a supine position on the mat, with knees flexed and feet fixed (17). The number of correct repetitions completed in 30 sec was recorded using a stopwatch.

Physical activity levels were assessed using an interview method with the Physical Activity Questionnaire for Older Children (PAQ-C). This questionnaire includes nine questions, each scored from one to five, with higher scores indicating greater physical activity levels. The PAQ-C assesses physical activities performed over the past seven days and includes two subdimensions: "physical activities out of school (PAQ-C-OS)" and "physical activities in school (PAQ-C-IS)" (18). The Turkish version of the PAQ-C was utilized in this study (18).

Statistical analysis

Data were analyzed using SPSS Statistics Version 22 (IBM Statistical Package). The distribution of variables was assessed with the Kolmogorov-Smirnov test. Descriptive statistics are presented as mean ± standard deviation or percentage (%). A one-way analysis of covariance (ANOVA) was used to compare continuous variables. The Kruskal-Wallis test was employed for discrete variables, while the chi-square test was utilized for categorical variables. Pairwise comparisons following the one-way ANOVA were conducted using the Bonferroni test, and those following the Kruskal-Wallis test were performed with the Mann-Whitney U test. Pearson or Spearman correlation analyses were used for intragroup correlations. The threshold for statistical significance was set at $p < 0.05$.

Results

Ninety adolescents (30 normal-weight, 30 overweight, and 30 obese) who met the inclusion criteria and volunteered to participate were included in the study. The sociodemographic characteristics of the participants are presented in **Table 1**. There were no statistically significant differences in the sociodemographic characteristics among the groups ($p > 0.05$).

Table 1 displays the waist and neck circumferences, BMI, BMI-Z scores, BMI percentiles, modified push-up repetitions, sit-up repetitions, PEF, PEF% pred, and total scores of the PAQ-C, along with in-school and out-of-school physical activity subscores for the adolescents. Significant differences among the groups were observed in waist and neck circumferences, weight, BMI, BMI-Z scores, and percentile values ($p < 0.05$).

Table 2 shows the anthropometric measurements, BMI, BMI-Z scores, and BMI percentiles for female and male adolescents within each group. Waist and neck circumferences, BMI values, BMI-Z scores, and

Table 1. Demographic and clinical features of the normal-weight, overweight and obese adolescents

		Normal-weight (n=30) Mean ± SD (Min–Max)	Overweight (n=30) Mean ± SD (Min–Max)	Obese (n=30) Mean ± SD (Min–Max)	p
Age (yr)		11.27 ± 0.94 (10–13)	11.40 ± 1 (10–13)	11.03 ± 0.80 (10–12)	0.351
Sex (n/%)	Female	16 (53.3)	16 (53.3)	11 (36.7)	0.328
	Male	14 (46.7)	14 (46.7)	19 (63.3)	
WC (cm)$^{\beta}$		67.20 ± 5.18 (54–78)	74.80 ± 7.26 (63–90)	91.43 ± 9.52 (77–112)	**< 0.0001**
NC (cm)$^{\beta}$		29.63 ± 1.67 (25–33)	30.98 ± 1.88 (28–34)	34.16 ± 2.79 (29.5–41)	**< 0.0001**
BMI (kg/cm^2)$^{\beta}$		19.15 ± 1.27 (17.4–21.9)	21.70 ± 1.25 (19.2–24.2)	28.64 ± 3.11 (23.7–34.6)	**< 0.0001**
BMI Percentile Value (%)$^{\beta}$		71.53 ± 10 (53.3–84.4)	91.47 ± 2.78 (86.7–94.6)	99.62 ± 0.32 (98.6–99.9)	**< 0.0001**
BMI-Z Score$^{\beta}$		0.57 ± 0.30 (0.08–1.01)	1.39 ± 0.19 (1.11–1.98)	2.83 ± 0.41 (2.08–3.68)	**< 0.0001**
Modified Push-Up (rep)$^{\alpha}$		14.67 ± 5.39 (5–26)	12.80 ± 5.56 (0–21)	8.77 ± 5.78 (0–22)	**< 0.0001**
Sit-Up (rep)$^{\alpha}$		10.43 ± 6.11 (0–21)	11.63 ± 5.62 (0–23)	12.23 ± 6.11 (2–25)	0.495
PEF (L/min)$^{\alpha}$		316.16 ± 63.43 (195–470)	311.33 ± 64.63 (170–440)	313.62 ± 65.99 (190–450)	0.959
PEF%$^{\alpha}$		102.50 ± 18.77 (56–139)	103.60 ± 19.15 (53–134)	97.10 ± 20.53 (67–150)	0.389
PAQ-C$^{\alpha}$		2.99 ± 0.85 (1.55–4.78)	3.29 ± 0.88 (1.08–4.69)	2.87 ± 0.76 (1.44–4.34)	0.147
PAQ-C-IS$^{\beta}$		2.95 ± 1.04 (1.33–5)	3.20 ± 0.80 (2.30–5)	2.96 ± 0.76 (1.66–4.66)	0.415
PAQ-C-OS$^{\beta}$		3.01 ± 0.97 (1.19–4.72)	3.38 ± 1.02 (1.10–4.71)	2.83 ± 0.92 (0.91–4.22)	0.063

$^{\alpha}$One-Way ANOVA, $^{\beta}$Kruskal-Wallis. SD, Standard Deviation; BMI, Body Mass Index; WC, Waist Circumference; NC, Neck Circumference; PEF, Peak Expiratory Flow; PAQ-C, Physical Activity Questionnaire for Children; IS, In-School; OS, Out-of-School; Rep, Repetitions.

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Table 2. Anthropometric measurements, BMI, BMI-Z score and BMI percentile values of female and male adolescents

	Normal-weight (n=30) Mean ± SD (Min–Max)	Overweight (n=30) Mean ± SD (Min–Max)	Obese (n=30) Mean ± SD (Min–Max)	p
Female				
WC (cm)^{β}	68 ± 5.91 (54–78)	73.37 ± 7.42 (64–89)	88.45 ± 6.94 (77–102)	**< 0.0001**
NC (cm)^{β}	29.40 ± 1.89 (25–32)	30.71 ± 1.91 (28–34)	33.77 ± 2.60 (30–37.5)	**< 0.0001**
BMI (kg/cm^2)^{β}	19.62 ± 1.37 (17.4–21.9)	21.92 ± 1.28 (19.8–24.2)	28.79 ± 2.72 (24.8–34.6)	**< 0.0001**
BMI Percentile Value (%)^{β}	71.18 ± 11.52 (53.3–84.4)	91.09 ± 3.14 (86.7–94.6)	99.59 ± 0.28 (99.1–99.9)	**< 0.0001**
BMI-Z Score^{β}	0.58 ± 0.34 (0.08–1.01)	1.37 ± 0.22 (1.11–1.98)	2.69 ± 0.33 (2.08–3.31)	**< 0.0001**
Male				
WC (cm)^{β}	66.28 ± 4.21 (62–77)	76.42 ± 6.98 (63–90)	93.15 ± 10.53 (79–112)	**< 0.0001**
NC (cm)^{β}	29.89 ± 1.41 (28–32)	31.28 ± 1.86 (28–34)	34.39 ± 2.95 (29.5–41)	**< 0.0001**
BMI (kg/cm^2)^{β}	18.62 ± 0.91 (17.6–20.8)	21.45 ± 1.21 (19.2–23.4)	28.56 ± 3.39 (23.7–33.8)	**< 0.0001**
BMI Percentile Value (%)^{β}	71.94 ± 8.34 (59.6–83.7)	91.91 ± 2.35 (87.8–94.9)	99.64 ± 0.35 (98.6–99.9)	**< 0.0001**
BMI-Z Score^{β}	0.55 ± 0.27 (0.22–0.98)	1.41 ± 0.15 (1.16–1.66)	2.92 ± 0.43 (2.19–3.68)	**< 0.0001**

^{β}Kruskal-Wallis. SD, Standard Deviation; BMI, Body Mass Index; WC, Waist Circumference; NC, Neck Circumference.

Table 3. Clinical features of female and male adolescents

	Normal-weight Mean ± SD (Min–Max)	Overweight Mean ± SD (Min–Max)	Obese Mean ± SD (Min–Max)	p
Female				
Modified Push-Up (rep)^{α}	12.50 ± 4.76 (5–20)	9.94 ± 5.32 (0–18)	8.55 ± 7.91 (0–22)	0.215
Sit-Up (rep)^{α}	8.44 ± 5.53 (0–19)	10.75 ± 6.41 (0–23)	10.36 ± 5.06 (5–22)	0.496
PEF (L/min)^{α}	309.68 ± 62.54 (195–430)	294.37 ± 65.08 (170–370)	282.27 ± 84.09 (190–450)	0.595
PEF%^{α}	98.93 ± 19.78 (56–124)	98.75 ± 21.04 (53–122)	87.72 ± 19.48 (67–125)	0.3
PAQ-C^{α}	2.85 ± 0.93 (1.55–4.78)	3.36 ± 0.88 (1.73–4.69)	3 ± 0.79 (1.75–4.34)	0.268
PAQ-C-IS^{β}	2.72 ± 1.14 (1.33–5)	3.14 ± 0.74 (2.33–5)	2.81 ± 0.85 (1.66–4.66)	0.195
PAQ-C-OS^{β}	2.91 ± 1.08 (1.19–4.72)	3.49 ± 1.15 (1.10–4.71)	3.10 ± 0.84 (1.61–4.18)	0.25
Male				
Modified Push-Up (rep)^{α}	17.14 ± 5.12 (8–26)	16.07 ± 3.85 (7–21)	8.89 ± 4.37 (0–15)	**< 0.0001**
Sit-Up (rep)^{α}	12.71 ± 6.13 (1–21)	12.64 ± 4.60 (4–19)	13.32 ± 6.53 (2–25)	0.936
PEF (L/min)^{α}	323.57 ± 65.96 (260–470)	330.71 ± 60.60 (190–440)	331.77 ± 46.25 (230–415)	0.912
PEF%^{α}	106.57 ± 17.34 (78–139)	109.14 ± 15.66 (81–134)	102.52 ± 19.58 (73–150)	0.565
PAQ-C^{α}	3.15 ± 0.75 (1.93–4.65)	3.21 ± 0.90 (1.08–4.45)	2.80 ± 0.76 (1.44–4.15)	0.293
PAQ-C-IS^{β}	3.20 ± 0.89 (1.66–4.66)	3.27 ± 0.88 (2.30–4.66)	3.05 ± 0.72 (2–4.66)	0.793
PAQ-C-OS^{β}	3.12 ± 0.86 (1.93–4.65)	3.26 ± 0.87 (1.54–4.35)	2.67 ± 0.95 (0.91–4.22)	0.15

^{α}One-Way ANOVA, ^{β}Kruskal-Wallis. SD, standard deviation; PEF, peak expiratory flow; Rep, repetition; PAQ-C, Physical Activity Questionnaire for Children; IS, in school; OS, out of school.

percentile values significantly differed across both sexes ($p < 0.05$).

The number of MPU repetitions was significantly lower in obese adolescents compared to their overweight ($p = 0.019$, 95% Confidence Interval –7.55/–0.51) and normal-weight peers ($p < 0.001$, 95% Confidence Interval –9.42/–2.38). However, peak expiratory flow, sit-up repetitions, and PEF% pred were similar across normal-weight, overweight, and obese adolescents ($p > 0.05$). Likewise, the PAQ-C total and subscores did not differ significantly among the three weight categories ($p > 0.05$) (**Table 1**).

The MPU and sit-up repetitions, PEF and PEF% pred, and physical activity levels were similar among normal-weight, overweight, and obese female adolescents ($p > 0.05$). The number of MPU repetitions was significantly lower in obese male adolescents compared to normal-weight ($p < 0.001$, 95% Confidence Interval –12.17/–4.33) and overweight males ($p < 0.001$, 95% Confidence Interval –11.09/–3.26). Sit-up repetitions, PEF, PEF% pred, and physical activity levels were similar in normal-weight, overweight, and obese male adolescents ($p > 0.05$) (see **Table 3**).

Table 4 shows the correlations between PEF% pred and other outcome measures for each group. No significant relationship was found between the PEF% pred and core performance, PAQ-C total score and subscores, and neck and waist circumferences in normal-weight adolescents ($p > 0.05$). In overweight adolescents, there was a significant positive correlation between PEF% pred and PAQ-C total scores ($p = 0.014$) and out-of-school physical activity subscores ($p = 0.039$). However, there was no significant correlation between PEF% pred and core performance, PAQ-C in-school physical activity subscores, or anthropometric measurements in overweight adolescents ($p > 0.05$). In obese adolescents, a significant positive correlation was observed between PEF% pred and the number of

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Table 4. The relationship of PEF% value with core performance, Physical activity level and anthropometric measurements in normal-weight, overweight and obese adolescents

			Modified push-Up[α]	Sit-up	PAQ-C[α]	PAQ-C-IS[α]	PAQ-C-OS[α]	Neck circumference[α]	Waist circumference[α]
Normal-weight	PEF %	r	0.175	0.294	0.297	0.326	0.232	0.039	–0.058
		p	0.355	0.115	0.111	0.079	0.216	0.838	0.762
Overweight	PEF %	r	0.355	0.25	0.443	0.358	0.379	0.105	0.24
		p	0.054	0.182	**0.014**	0.052	**0.039**	0.581	0.202
Obese	PEF %	r	0.399	0.158	–0.110	0.031	–0.164	–0.184	–0.247
		p	**0.029**	0.403	0.562	0.871	0.388	0.33	0.189

[α]Pearson Correlation. WC, waist circumference; NC, neck circumference; PEF, peak expiratory flow; PAQ-C, Physical Activity Questionnaire for Children; IS, in school; OS, out of school.

modified push-up repetitions (p = 0.029). There was no significant relationship between PEF% pred and sit-up repetitions, PAQ-C total scores and subscores, neck circumference, or waist circumference in obese adolescents (p > 0.05).

Discussion

This study revealed that MPU performance, a key indicator of core strength, was lower in obese adolescents than in their overweight or normal-weight peers and that MPU performance was associated with PEF% pred in obese adolescents. Peak expiratory flow, sit-up performance, and physical activity habits were similar among normal-weight, overweight, and obese adolescents. Additionally, PEF% pred was correlated with physical activity levels in overweight adolescents but not in their obese counterparts.

Several studies have reported that childhood obesity is associated with decreased PEF across various nations and age groups from 6 to 15 yr (5, 19). Conversely, Babu *et al.* observed that PEF was significantly higher in obese children compared to normal and overweight children aged 8–13 yr (20). Liyanage *et al.* reported that BMI had no significant relationship with any pulmonary function parameters, including PEF, in children aged 9–15 yr (21). In our study, the adolescents were aged between 10–13 yr and all resided in the same local area. Given that PEF is influenced by sex and age, we also calculated PEF% pred to control for these effects (16). Although PEF and PEF% pred values were lower in obese adolescents than in their normal-weight or overweight peers, no significant differences were found in our statistical analysis. The varied results in the literature could be due to different PEF measurement methods, obesity classifications, age, sex, ethnic origins, or participants' physical characteristics (21). Considering these varied results, future studies should consider analyzing population-specific reference percentiles or formulas for respiratory function.

Increased abdominal and visceral adiposity may lead to excessive stretching of core muscle fibers, resulting in a length-tension disadvantage and increased metabolic demand, contributing to muscle dysfunction and impaired core performance (22). Duncan *et al.* assessed the physical performance of obese, overweight, and normal-weight children and found that obese children had lower performance scores than their normal-weight peers (12). Consistent with the literature, our findings also showed that MPU repetitions, which assess physical performance, were lower in obese adolescents compared to their normal-weight and overweight peers. Surprisingly, no difference was observed between the groups in sit-up repetitions, another method to assess physical performance. Esco *et al.* analyzed the relationship between push-up and sit-up tests and anthropometric measurements and found that the push-up test was related to abdominal skinfolds, whereas the sit-up test was not (23). Another study indicated that the push-up test requires combined activation of the shoulders, arms, upper body, and abdomen, whereas the sit-up test, primarily activating the abdomen, demands more muscle activation and creates a higher workload in the abdomen (24). Wang *et al.* reported that the sit-up test was not related to either BMI or body fat mass in children and noted that findings in the literature were mixed and sometimes contradictory (25). They suggested that the sit-up test may relate not only to muscular endurance but also to flexibility, agility, explosive power, and body shape; thus, conflicting results have been reported. Considering these multifactorial variables that affect the tests, we may conclude that our study's observed lower MPU repetition may be due to the different application methods, components, and relationships with abdominal tissue.

Core exercises improve lung function by increasing intra-abdominal pressure and decreasing intrathoracic pressure, thereby enhancing airflow (26). The strength and coordination of the expiratory muscles, particularly the abdominal muscles, are crucial determinants of PEF (27). Core exercises are effective in improving PEF% pred (28), respiratory muscle strength, and physical activity levels across various populations (29). One potential mechanism is that core exercises enhance respiratory function by strengthening core muscles. To our knowledge, this is the first study to examine the relationship between core performance and PEF% pred, which assesses respiratory function in obese adolescents.

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We found a correlation between PEF% pred and MPU repetitions in obese adolescents but not in their overweight counterparts. These results suggest that enhancing core performance might be effective in maintaining or improving respiratory function in adolescents with obesity. Numerous studies have established a link between core performance and respiratory function (30, 31). This relationship is often attributed to the primary roles of the diaphragm and abdominal muscles in both core performance and respiratory function. Our findings that core performance is associated with respiratory function in obese adolescents align with existing literature and likely arise from similar mechanisms. However, the significant association of the push-up test with abdominal adipose tissue (23) and the prevalence of abdominal fat in obese adolescents may explain why the relationship between core performance and respiratory function was observed only in obese adolescents and not in overweight or normal-weight ones.

Overweight and obese children are generally less active than their normal-weight peers (32). Participation in physical activity is influenced by physical opportunities, cultural factors, social environment, economic conditions, demographic factors (age, sex, heredity), psychological factors (mood state, motivation), and mental and emotional factors (33). In our study, we observed a correlation between the predicted PEF% and the PAQ-C total score and out-of-school physical activity sub-scores in overweight adolescents but not in their obese peers. This finding underscores the importance of increasing physical activity in overweight adolescents to prevent obesity and maintain normal respiratory function. Furthermore, since both the MPU and PEF maneuvers are directly related to abdominal muscles (34, 35), it suggests a link between MPU performance and PEF. The MPU repetitions in obese adolescents were significantly lower than in overweight adolescents. Given that MPU reflects core performance, a determinant of physical activity (36), the absence of a relationship between physical activity and respiratory function in obese adolescents— despite low core performance and respiratory function— might be attributed to the insensitivity and lack of objectivity in the physical activity measurement method used in our study, as noted in recent research (37).

Our study had certain limitations. Due to time constraints imposed by the school administration during the legal permission process, we could not evaluate respiratory function using a spirometer, body composition with bioelectrical impedance analysis, or core performance based on a broader range of movements. However, we opted for clinically valid practice measurements in our assessments without deviating from our objectives.

This study demonstrated that MPU performance, an indicator of core strength, was lower in obese adolescents than in their overweight or normal-weight peers and that MPU performance was associated with predicted PEF% in obese adolescents. Peak expiratory flow, sit-up performance, and physical activity habits were consistent across normal-weight, overweight, and obese adolescents.

Conclusions

In conclusion, this study revealed that MPU performance, an indicator of core strength, was lower in obese adolescents than in overweight adolescents or those in the normal weight range. Additionally, MPU performance was correlated with PEF% pred in obese adolescents. Furthermore, PEF% pred was associated with physical activity levels in overweight adolescents but not in their obese counterparts. Based on these findings, we believe that further research is necessary to explore the protective or therapeutic effects of core exercises on respiratory function in obese children and adolescents.

Conflict of interests: The authors declare no conflicts of interest.

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