EMU Journal of Health Sciences
DAÜ Sağlık Bilimleri Dergisi

DOI:

Geliş Tarihi (Received): 26.01.2026 Kabul Tarihi (Accepted): 20.5.2026 Online Yayın Tarihi (Published): 30.4.2026

Original Research Article/Orijinal Araştırma Makalesi

Associations Between Body Composition, Posture, and Aerobic Capacity in Obese Adolescents

Ayşe Ş. Kaya, Zehra Güçhan Topcu

Eastern Mediterranean University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Famagusta, North Cyprus, Mersin 10 Türkiye

Abstract

Aim: The aim of our study is to investigate the relationships among body composition, posture and aerobic capacity in obese adolescents.
Materials and Methods: A total of 93 obese adolescents aged 11 to 14, 49 female and 44 male, were included in the study. Body Mass Index (BMI), Bioelectrical Impedance Analysis (BIA) (with Tanita BC601) and waist circumference measurements were performed for the children's body compositions. For biomechanical variables, lumbar lordosis angle (flexiruler) and forward head posture were measured. Foot Posture İndex (API-6) was used for foot biomechanics. Aerobic capacity was measured using the Cooper Test. Heart rate was recorded before and after the test. SPSS 19 statistical software was used for statistical analysis (IBM SPSS Statistics 19, SPSS inc., an IBM Co., Somers, NY).
Results: As a result, it was determined that there was a positive relationship between body fat percentage and lumbar lordosis angle and heart rate, and a negative relationship between head anterior tilt angle, aerobic capacity and correct posture ($p<0.05$). There was a positive correlation between BMI value and lumbar lordosis angle and heart rate, and a negative correlation between postural smoothness and aerobik capacity ($p<0.05$). As the percentile values of adolescents increase, lordosis angle and postural problems increase and aerobic capacity decreases ($p<0.05$).
Conclusion: In conclusion, higher adiposity in obese adolescents is linked to poorer posture and reduced aerobic capacity. So obesity management requires a holistic approach that considers not only body composition but also postural assessment and aerobic capacity.

Keywords: aerobic capacity, body composition, posture

Obez Ergenlerde Vücut Yapısı, Postür ve Egzersiz Kapasitesi Arasındaki İlişkiler

Özet

Amaç: Çalışmamızın amacı obez adölesanlarda vücut kompozisyonu, postür ve aerobik kapasite arasındaki ilişkileri araştırmaktır.
Materyal ve Metod: Yaşları 11 ile 14 arasında olan 49 kız ve 44 erkek olmak üzere toplamda 93 obez adölesan çalışmaya dahil edildi. Çocukların vücut kompozisyonu için Beden Kütle İndeksi (BKİ), Biyoelektrik İmpedans Analizi (BİA) (Tanita BC601 ile) ve bel çevresi ölçümleri yapıldı. Postürdeki biyomekanik değişkenler için lumbal lordoz açısı (fleksiruler ile) ve başın öne tilti ölçüldü. Ayak biyomekaniği için ise ayak postür indeksi (APİ-6) kullanıldı. Aerobik kapasite ölçümü Cooper Testi ile yapıldı. Test öncesi ve sonrası kalp atım hızı kaydedildi. İstatistiksel analiz için SPSS 19 istatistik yazılımı kullanıldı (IBM SPSS Statistics 19, SPSS inc., an IBM Co., Somers, NY).
Bulgular: Sonuç olarak vücut yağ yüzdesi ile lumbal lordoz açısı, kalp atım hızı arasında pozitif yönlü, başın anterior tilt açısı, aerobik kapasite, postüral düzgünlük arasında negatif yönlü ilişki olduğu tespit edildi ($p<0,05$). BKİ değeri ile lumbal lordoz açısı, kalp atım hızı arasında pozitif yönlü, postüral düzgünlük, aerobik kapasite arasında negatif yönlü ilişki tespit edildi ($p<0,05$). Adölesanların persentil değerleri arttıkça lordoz açısı ile postüral problemler artmakta ve aerobik kapasite azalmaktaydı ($p<0,05$).
Sonuç: Sonuç olarak, obez ergenlerdeki yüksek yağ oranı, daha kötü duruş ve azalmış aerobik kapasitesiyle ilişkilidir. Bu nedenle obezite yönetimi, yalnızca vücut kompozisyonunu değil, aynı zamanda duruş değerlendirmesini ve aerobik kapasitesini de dikkate alan bütüncül bir yaklaşım gerektirir.

Anahtar Kelimeler: aerobik kapasite, vücut kompozisyonu, postür

Introduction

Childhood and adolescent obesity has rapidly become a growing global epidemic.[1] As the duration and severity of obesity increase in children and adolescents, complications tend to occur earlier and with greater frequency. Early detection of metabolic and cardiovascular disorders in obese children and adolescents is essential for preventing potential long-term complications.[2]

During adolescence, obesity becomes more complex with the involvement of psychosocial problems and is associated with various additional health issues.[3] It has been reported that as physical well-being deteriorates in overweight and obese children, their quality of life declines accordingly.[4] Adolescent obesity requires early diagnosis and intervention to prevent the progression to cardiometabolic diseases in adulthood. Nevertheless, the prevalence of undiagnosed comorbidities remains high among obese individuals at a young age. A study conducted in New Zealand involving obese adolescents reported that 40% of participants had undiagnosed metabolic syndrome, with a prevalence twice as high in males compared to females. Dyslipidemia was identified in 69% of participants, more than half had prediabetes, and 31% had hypertension. Furthermore, the risk of metabolic syndrome was shown to increase with the severity of obesity.[5]

Obesity is known to be associated with impaired posture and hyperlordosis. It has been reported that hyperlordosis increases with rising body mass index (BMI) in adolescents.[6] Significant relationships have been identified between postural subtypes and BMI, body weight, height, and sex. Adolescents without a neutral posture experience more back pain compared to those with a neutral posture, suggesting that an increase in neutral thoracolumbopelvic alignment is associated with a reduction in back pain.[7] Obesity has also been shown to negatively affect the development of the longitudinal arch in adolescents, leading to pes planus and increased plantar pressure, which are among the commonly observed postural problems.[8,9]

Although VO_2peak does not appear to be directly associated with fat mass, obesity is well recognized as a risk factor for cardiovascular diseases. Moreover, obesity is currently defined as a chronic inflammatory disease, inevitably affecting the vascular system. Cardiovascular impairments may reduce oxygen delivery and consequently compromise aerobic performance.[10]

For these reasons, identifying the interrelationships among obesity-related complications during adolescence is expected to guide both preventive strategies and therapeutic interventions. Accordingly, the aim of this study is to determine the relationships among body composition, posture, and aerobic capacity in obese adolescents.

Materials and Methods

Participants

This study was conducted among voluntary students aged 11–14 years who were living in Türkiye and attending schools in the Afşin district of Kahramanmaraş province, with a body mass index (BMI) percentile of 95 or above. A statistical power analysis was performed to determine the required sample size. Based on the study by Ostojic et al. (2011), entitled "Correlation between Fitness and Fatness in 6–14-Year-Old Serbian School Children", the effect size for the relationship between VO_2peak and body fat percentage was reported to be high. Accordingly, assuming an effect size of 0.40, an alpha level of 0.05, and a statistical power of 95% ($1-\beta = 0.95$), the minimum required sample size was calculated as 63 participants using G*Power software version 3.1.9.2.[11]

Adolescents aged 11–14 years with BMI percentile values of 95 or higher and a physician's report confirming their suitability for participation in the planned assessments were included in the study. Exclusion criteria comprised the presence of orthopedic or neurological conditions that could contraindicate aerobic testing; chronic and/or congenital diseases such as diabetes or asthma; participation in a diet program within the previous three months;[12] and engagement in professional physical activity during the previous three months.[13]

After obtaining permission from the Ministry of Education, informed consent forms were distributed to approximately 350 students from four different secondary schools. The students were screened, and the families of eligible participants were contacted. The purpose of the study was explained both to the parents and to the participants. Participants were scheduled during the second or third lecture period of the day (09:00–10:00 a.m.). After providing informed consent, they were instructed in advance to consume breakfast, avoid being excessively full, maintain adequate hydration on the day of testing, and wear comfortable clothing suitable for walking and running.

Initially, height and body weight measurements were obtained from 240 children whose parents provided written informed consent, and body mass index (BMI) was calculated. Families were requested to obtain medical clearance reports from their physicians. After the reports were received, the date and time for assessments were scheduled. Participants were instructed to attend the assessment session wearing appropriate clothing and sports shoes.

Among the students whose BMI percentile values were ≥95th percentile, measurements were performed on 100 adolescents. Seven participants were excluded. A total of 93 adolescents were included.

This study was approved by the Eastern Mediterranean University Health Ethics Subcommittee with decision number 2019-0018 dated 21.02.2019. Written informed consent was obtained from the parents or legal guardians of all participating children.

After recording sociodemographic information, body composition was assessed using body mass index, waist circumference measurement, and body component analysis via bioelectrical impedance analysis (BIA). A body composition analyzer (Tanita BC601) was used for this purpose. To evaluate postural abnormalities, the craniovertebral angle was measured to assess anterior head tilt, and lumbar lordosis was measured using a flexicurve ruler. Foot biomechanics were evaluated using the Foot Posture Index, and aerobic capacity was determined using the Cooper test. Prior to data collection, participants were informed about the measurement procedures, the devices and instruments to be used were introduced, and the test protocol of aerobic capacity was explained.

Sociodemographic Information

Participants' age, gender, and presence of a diagnosed illness were recorded.

Body Composition

Waist Circumference

The measurement was taken using a tape measure at the narrowest point between the iliac crest and the subcostal region while the participant was standing in a relaxed and loose position with arms at the sides and feet together.[14]

Body Mass Index

Body mass index (BMI=kg/m2) was calculated by recording the participants' body weight (kg) and height (in m). Height was measured with a standard tape measure fixed to the wall, and body weight was measured using a Tanita BC601 device. The child's date of birth, height, and gender were recorded in the software used. Since BMI is affected by age and gender factors, percentage values were determined according to the percentile tables of the World Health Organization's body mass index and recorded as ≥95%, >97%, and >99%.[15]

Bioelectrical Impedance Analysis

Participants' body fat percentage (%), weight, and body mass index were determined using a BIA device (Tanita BC601). Students were asked to remove any metal objects and stand barefoot on the device. Their heels and toes were positioned to fully contact the metal points on the device, while their hands gripped the electrodes. They remained motionless until the warning sound was heard. The results were recorded using software.[16]

Biomechanical Measurements

Anterior Head Tilt

To determine the anterior head tilt angle, the craniovertebral angle was measured using photographic analysis. Participants were instructed to stand upright, and a lateral photograph was taken. In the captured image, the spinous process of the C7 vertebra and the tragus were marked. The angle formed between the line connecting these two anatomical landmarks and the horizontal plane was recorded as the craniovertebral angle.[17]

Lumbar Lordosis Angle

A 50-cm flexible ruler (flexicurve) was used to assess the lumbar lordosis angle. The spinous processes of the S2 and L1 vertebrae were identified and marked as reference points. The flexicurve was positioned along the lumbar region, and the contour was traced. The angle was calculated using the following formula and recorded accordingly:[18] The lordosis angle was calculated using the formula: Lordosis angle = $4 \times \arctan(2H / L)$, where L represents the linear distance between the upper and lower reference vertebrae, and H represents the maximum perpendicular distance from the apex of the curvature to the line connecting these vertebrae).

Foot Biomechanics

Foot biomechanics were evaluated using the Foot Posture Index-6 (FPI-6). Six criteria related to the rearfoot and forefoot were assessed while the child was in both standing and sitting relaxed positions. Rearfoot assessment included palpation of the talar head, observation of the curvature above and below the lateral malleolus, and evaluation of calcaneal inversion/eversion. Forefoot assessment included bulging in the talonavicular joint region, medial longitudinal arch (MLA) structure, and forefoot abduction/adduction relative to the rearfoot.[19]

Each criterion was scored on a scale ranging from −2 to +2. Total scores ranged from −12 to +12 for both the right and left feet and were recorded separately for sitting and standing positions. According to the index classification, scores between −5 and −12 indicate high supination, −1 to −4 indicate supination, 0 to +5 indicate normal posture, +6 to +9 indicate pronation, and ≥ +10 indicate high pronation. A cut-off value of +6 was used for pes planus, with increasing scores reflecting greater reduction in the medial longitudinal arch. [19]

Aerobic Capacity

Aerobic capacity was assessed using the Cooper test, originally derived from Balke's 15-minute run test (1963) and later adapted by Dr. Kenneth Cooper into 12-minute and 1.5-mile versions. Heart rate was measured before and immediately after the test. The test protocol was explained to each participant in an age-appropriate manner. At the start signal, participants were instructed to run or walk as far as possible within 12 minutes. At the end signal, the nearest 100-m mark reached by the participant was recorded. Total running distance was entered into the formula to calculate VO_2peak:[20]

$$VO_2peak = (\text{Distance covered (m)} - 504.9) / 44.73$$

Statistical Analysis

Statistical analysis of research data was performed using the Statistical Package for Social Sciences (SPSS) 25.0 software. Kolmogorov-Smirnov and Shapiro-Wilk tests were used to determine whether the data were normally distributed. The result was $p < 0.05$, indicating that the data did not conform to a normal distribution. Therefore, non-parametric hypothesis tests were used in the study. Spearmant's test was used for correlation tests.

The Kruskal-Wallis H test was used to compare anterior head tilt, lumbar lordosis angle, API scores, aerobic capacity, distance taken in the Cooper test, and heart rate values according to the body mass index percentile values of adolescents. In the study, descriptive statistics for continuous variables were presented as mean ± standard deviation, median, and categorical variables as number and percentage.

A significance level of $p < 0.05$ was selected.

Results

After obtaining permission from the Ministry of Education, informed consent forms were distributed to approximately 350 students from four different secondary schools. The students were screened, and the families of eligible participants were contacted. The purpose of the study was explained both to the parents and to the participants.

Initially, height and body weight measurements were obtained from 240 children whose parents provided written informed consent, and body mass index (BMI) was calculated. Families were requested to obtain medical clearance reports from their physicians. After the reports were received, the date and time for assessments were scheduled. Participants were instructed to attend the assessment session wearing appropriate clothing and sports shoes.

Among the students whose BMI percentile values were ≥95th percentile, measurements were performed on 100 adolescents. Seven participants were excluded. A total of 93 adolescents were included.

Table 1. Demographic and Anthropometric Characteristics of Adolescents (n=93).

	Numer (n)	**Percent (%)**	
Gender			
Female	49	52.69	
Male	44	47.31	
Years			
11	33	35.48	
12	25	26.88	
13	19	20.43	
14	16	17.20	
	$\bar{x} \pm s$ (95% CI)	**Min-Max**	**Median**
Height (cm)	157.29 ± 7.43 (155.76–158.82)	142–175	158
Body Weight (kg)	67.18 ± 9.96 (65.13–69.24)	47.3–92.8	66.1
BMI (kg/m²)	27.15 ± 2.84 (26.56–27.73)	22.5–36.6	26.6
Body Fat (%)	34.29 ± 5.94 (33.07–35.52)	18–49.9	34.8
Waist Circumference (cm)	88.01 ± 7.30 (86.51–89.52)	72–110	87

Table 1 presents the demographic characteristics and body composition parameters of the participants. The mean height of the adolescents was 157.29 ± 7.43 cm, mean body weight was 67.18 ± 9.96 kg, mean BMI was 27.15 ± 2.84 kg/m², mean body fat percentage was 34.29 ± 5.94%, and mean waist circumference was 88.01 ± 7.30 cm (Table 1).

It was determined that 21.5% of the adolescents had BMI percentile values >95th percentile, 41.9% had values >97th percentile, and 36.6% had values >99th percentile (Figure 1).

Descriptive statistics of head anterior tilt angle, lumbar lordosis angle, Foot Posture Index (FPI-6), aerobic capacity, total running distance, and heart rate values are presented in Table 2.

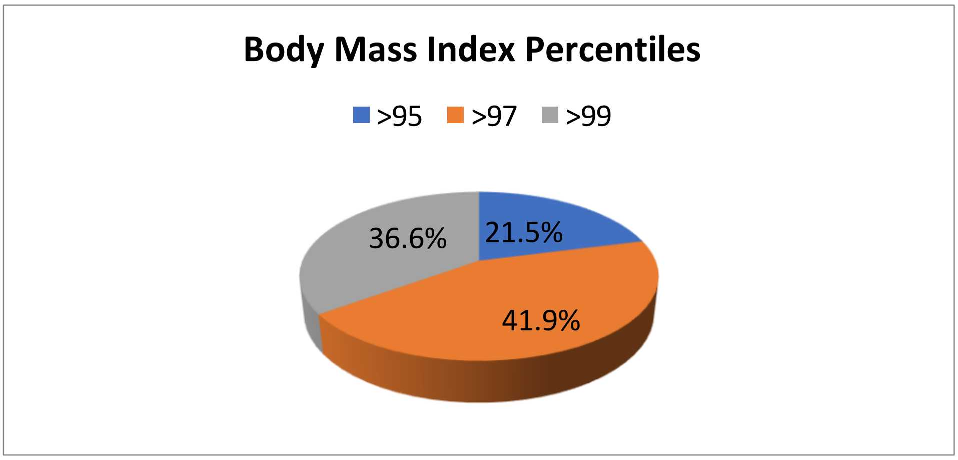

Figure 1. Body mass index percentiles of the adolescents

Table 2. Postural, Aerobic and Cardiovascular Parameters (n=93)

	n	$\bar{x} \pm s$ (95% CI)	Min-Max	Median
Head Anterior Tilt Angle (°)	93	44.80 ± 4.58 (43.85–45.74)	35 - 58	45
Lumbar Lordosis Angle (°)	93	79.09 ± 17.01 (75.58–82.59)	42.56 – 144.8	77.16
Foot Posture Index left (sitting)	93	3.04 ± 1.98 (2.63–3.45)	0 - 8	3
Foot Posture Index right (sitting)	93	3.18 ± 1.99 (2.77–3.59)	0 - 8	3
Foot Posture Index left (standing)	93	5.17 ± 2.12 (4.73–5.61)	0 - 10	5
Foot Posture Index right (standing)	93	5.32 ± 2.09 (4.89–5.75)	0 - 10	6
Cooper Test Distance (m)	93	1404.78 ± 265.60 (1350.09–1459.48)	1000 - 2400	1300
VO_2peak (mL/kg/min)	93	20.12 ± 5.94 (18.90–21.34)	11.07 – 42.37	17.78
Heart Rate Pre-test (bpm)	93	94.24 ± 7.89 (92.61–95.86)	80 - 112	92
Heart Rate Post-test (bpm)	93	106.06 ± 7.30 (104.56–107.57)	86 - 118	106
Heart Rate Change (bpm)	93	11.83 ± 5.61 (10.67–12.98)	4 - 28	12

Correlations between BMI values and head anterior tilt angle, lumbar lordosis angle, FPI-6, aerobic capacity, total running distance, and heart rate change were analyzed (Table 3).

Table 3. Correlations Between BMI and Postural, Aerobic and Cardiovascular Parameters (n = 93)

		Body Mass Index (kg/m^2)
Head Anterior Tilt Angle (°)	r	-0.114
	p	0.276
Lumbar Lordosis Angle (°)	r	0.373
	p	0.000**
Foot Posture Index left (sitting)	r	0.025
	p	0.812
Foot Posture Index right (sitting)	r	0.075
	p	0.475
Foot Posture Index left (standing)	r	0.017
	p	0.871
Foot Posture Index right (standing)	r	0.042
	p	0.688
Cooper Test Distance (m)	r	-0.232
	p	0.025*
VO_2peak (mL/kg/min)	r	-0.232
	p	0.025*
Heart Rate Change (bpm)	r	0.274
	p	0.008*

**p<0.05 ** p<0.001(Spearman test)*

Correlations between body fat percentage and head anterior tilt angle, lumbar lordosis angle, FPI-6, aerobic capacity, total running distance, and heart rate change are shown in Table 4.

Comparisons of head anterior tilt angle, lumbar lordosis angle, FPI-6, aerobic capacity, total running distance, and heart rate change according to BMI percentile categories are presented in Table 5.

Table 4. Correlations Between Body Fat Percentage and and Postural, Aerobic and Cardiovascular Parameters (n = 93)

		Body Fat Percentage (%)
Head Anterior Tilt Angle (°)	r	-0.269
	p	0.009**
Lumbar Lordosis Angle (°)	r	0.348
	p	0.001**
Foot Posture Index left (sitting)	r	0.116
	p	0.268
Foot Posture Index right (sitting)	r	0.154
	p	0.140
Foot Posture Index left (standing)	r	0.100
	p	0.343
Foot Posture Index right (standing)	r	0.145
	p	0.165
Cooper Test Distance (m)	r	-0.356
	p	0.000**
VO_2peak (mL/kg/min)	r	-0.356
	p	0.000**
Heart Rate Change (bpm)	r	0.210
	p	0.043*

**p<0.05 **p<0.001 (Spearman test)*

Table 5. Comparison of Head Anterior Tilt, Lumbar Lordosis Angle, API, Aerobic Capacity, Distance Run, and Heart Rate Variability Values According to Adolescents' Body Mass Index Percentile Values (n=93).

	BMI	N	$\bar{x} \pm s$	95% CI	Min-Max	X^2	p	Difference
Head Anterior Tilt Angle (°)	>95	21	46.25 ± 4.98	43.92 – 48.58	39 – 58			
	>97	44	44.56 ± 4.59	43.08 – 46.05	35 – 54	2.243	0.326	
	>99	35	44.21 ± 4.26	42.72 – 45.69	37 – 54			
Lumbal lordosis angle (^{0})	>95	21	69.72 ± 11.05	64.55 – 74.89	42.56 – 87.96			a-c
	>97	44	75.82 ± 11.65	72.04 – 79.6	51.36 – 102.56	15.665	0.000*	b-c
	>99	35	88.34 ± 20.65	81.14 – 95.55	45.68 – 144.8			
Foot Posture Index Left (sitting)	>95	21	2.3 ± 1.13	1.77 – 2.83	1 – 5			
	>97	44	3.59 ± 2.26	2.86 – 4.32	0 – 8	4.931	0.085	
	>99	35	2.85 ± 1.91	2.19 – 3.52	0 – 7			
Foot Posture Index right (sitting)	>95	21	2.35 ± 1.76	1.53 – 3.17	0 – 6			
	>97	44	3.56 ± 2.23	2.84 – 4.29	0 – 8	4.645	0.098	
	>99	35	3.24 ± 1.72	2.63 – 3.84	0 – 7			
Foot Posture Index left (standing)	>95	21	4.45 ± 2.33	3.36 – 5.54	0 – 10			
	>97	44	5.56 ± 2.1	4.88 – 6.24	1 – 10	4.794	0.091	
	>99	35	5.15 ± 1.97	4.46 – 5.83	1 – 10			
Foot Posture Index right (standing)	>95	21	4.5 ± 2.33	3.41 – 5.59	0 – 10			
	>97	44	5.62 ± 2.22	4.9 – 6.33	1 – 10	3.972	0.137	
	>99	35	5.47 ± 1.69	4.88 – 6.06	3 - 10			
Cooper Test Distance (m)	>95	21	1502 ± 323.83	1350.44 – 1653.56	1150 - 2200			a-b
	>97	44	1437.31 ± 276.48	1347.68 – 1526.93	1075 - 2400	6.115	0.047	a-c
	>99	35	1310.29 ± 179.13	1247.79 – 1372.8	1000 - 1600			
VO_2peak (mL/kg/min)	>95	21	22.29 ± 7.24	18.9 – 25.68	14.42 – 37.9			a-b
	>97	44	20.85 ± 6.18	18.84 – 22.85	12.75 – 42.37	6.115	0.047	a-c
	>99	35	18.01 ± 4	16.61 – 19.4	11.07 – 24.48			
Heart Rate Change (bpm)	>95	21	12.7 ± 7.43	9.22 – 16.18	4 - 28			
	>97	44	12.72 ± 5.26	11.01 – 14.42	4 - 24	3.587	0.166	
	>99	35	10.29 ± 4.49	8.73 – 11.86	4 - 20			

**p<0.05 ** p<0.001 (Kruskal-Wallis H test) a= >0.95, b= >0.97, c= >0.99*

Discussion

In this study, the relationships among body composition, postural parameters, and aerobic capacity in obese adolescents were investigated. The findings demonstrated that body fat percentage was positively associated with lumbar lordosis angle and heart rate, and negatively associated with anterior head tilt angle and aerobic capacity. Similarly, body mass index (BMI) showed positive correlations with lumbar lordosis angle and heart rate, and a negative correlation with aerobic capacity. As adolescents' percentile values increased, lumbar lordosis angle increased, whereas postural alignment and aerobic capacity decreased. However, no statistically significant relationship was found between VO_2peak and waist circumference, anterior head tilt angle, or lumbar lordosis angle.

In the present study, the mean body fat percentage was 34.16 ± 5.83%, which is comparable to values reported in studies including only obese children.[21] Considering the obesity cut-off values defined by the American Council on Exercise (≥32% for girls and ≥25% for boys), the obesity status of our sample is confirmed.[22]

With respect to postural assessments, the literature reports that forward head protrusion is common in overweight and obese children.[23] A decrease in the craniovertebral angle is associated with forward head posture and may lead to clinical consequences such as headaches, restricted cervical mobility, and temporomandibular joint disorders.[24]

In the present study, the anterior head tilt angles were lower than the craniovertebral angle values reported in healthy children, suggesting that obesity may negatively affect cervical posture.[25] Moreover, the negative association between anterior head tilt angle and body fat percentage indicates that the degree of adiposity may influence head posture. The limited number of studies directly examining the relationship between body fat percentage and craniovertebral angle highlights the potentially pioneering nature of this finding.[26] Consistent with our results, Güçhan reported that increased body weight in obese children in the control group could adversely affect head posture. Accordingly, close monitoring of cervical posture in obese adolescents is considered important.

The lumbar lordosis angle in our study (79.22 ± 16.49°) was markedly higher than values reported in healthy children.[27] Obesity is known to increase lumbar lordosis due to anterior displacement of the center of gravity.[28] Zwierzchowska et al.[29] reported that BMI was associated with lumbar lordosis; however, no significant difference was observed between obese and non-obese individuals. In contrast, both BMI and body fat percentage were associated with lumbar lordosis angle in our study, which may be explained by the inclusion of only obese adolescents and differences in measurement methods. In a prospective study, Smith et al.[6] demonstrated that increasing BMI z-scores were strongly associated with hyperlordotic and sway-back postures, which is consistent with our findings.

From a foot biomechanics perspective, increased body weight has been reported to increase the tendency toward pes planus and pronation.[30] In our study, higher API-6 scores, particularly in standing measurements, indicate a tendency toward pronation in obese adolescents. Compared with the lower API values reported by Carvalho et al. in a study including different BMI groups,[31] the inclusion of only obese individuals in our sample may explain this discrepancy. Although a weak but significant relationship was reported between BMI and API in the literature,[32] the limited association observed in our study may be attributed to the homogeneous nature of the sample or the limited sensitivity of the API scoring system in detecting such relationships.

Regarding aerobic capacity, VO_2peak values decreased as body fat percentage and BMI increased. This finding is consistent with studies conducted in adolescents and young adults.[33-35] Body fat percentage has been suggested to be a more sensitive indicator than BMI for predicting aerobic capacity.[33] High adiposity limiting cardiorespiratory capacity has been associated with an increased long-term cardiovascular risk.[35] Despite all participants being obese, the observed association between variations in body fat percentage and aerobic capacity is clinically important for assessment and intervention planning. In line with studies reporting that BMI can predict VO_2max,[36] a significant relationship between BMI and aerobic capacity was also identified in our study.

A limitation of this study is that the applied tests were field-based assessments, which may present disadvantages in terms of validity and reliability. Particularly for postural evaluations, the use of more objective measurement methods in clinical settings may influence the results and should be considered in future studies.

Conclusion

In conclusion, increased body fat percentage in obese adolescents is associated with postural impairments, lumbar hyperlordosis, alterations in foot biomechanics, and reduced aerobic capacity. These findings highlight the need for multidisciplinary approaches in obesity management that extend beyond weight control to include postural assessment, musculoskeletal protection, and enhancement of cardiorespiratory fitness. Early comprehensive assessment and intervention may reduce long-term functional impairments and overall health burden.

Correspondig Author/Sorumlu Yazar*: Assoc. Prof. Zehra Güçhan Topcu, PT. Eastern Mediterranean University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Famagusta, Northern Cyprus, Mersin-10 Türkiye, E-mail: zehra.guchan@emu.edu.tr*

References

1. Zhang X, Liu J, Ni Y, Yi C, Fang Y, Ning Q, Shen B, Zhang K, Liu Y, Yang L, Li K. Global prevalence of overweight and obesity in children and adolescents: a systematic review and meta-analysis. JAMA pediatrics. 2024;178(8):800-13.
2. Szczudlik E, Stępniewska A, Bik-Multanowski M, Brandt-Heunemann S, Flehmig B, Małecka-Tendera E, Mazur A, Petriczko E, Ranke MB, Wabitsch M, Zachurzok A. The age of the obesity onset is a very important factor for the development of metabolic complications and cardiovascular risk in children and adolescents with severe obesity. European journal of pediatrics. 2024;83(9):3833-41.
3. World Health Organization, (2014). Health for the world's adolescents: a second chance in the second decade. WHO http://www.who.int/maternal_child_adolescent/documents/second-decade/en/, (accessed in January 2026)
4. Meixner L, Cohrdes C, Schienkiewitz A, Mensink GB. Health-related quality of life in children and adolescents with overweight and obesity: results from the German KIGGS survey. BMC Public Health. 2020;20(1):1722.
5. Leong KS, Jayasinghe TN, Wilson BC, Derraik JG, Albert BB, Chiavaroli V, Svirskis DM, Beck KL, Conlon CA, Jiang Y, Schierding W. High prevalence of undiagnosed comorbidities among adolescents with obesity. Scientific reports. 2020;10(1):20101.
6. Smith AJ, O'Sullivan PB, Beales DJ, De Klerk N, Straker LM. Trajectories of childhood body mass index are associated with adolescent sagittal standing posture. International Journal of pediatric obesity. 2011;6(sup3):e97-106.
7. Smith A, O'Sullivan P, Straker L. Classification of sagittal thoraco-lumbo-pelvic alignment of the adolescent spine in standing and its relationship to low back pain. Spine. 2008;33(19):2101-7.
8. Villarroya MA, Esquivel JM, Tomás C, Moreno LA, Buenafé A, Bueno G. Assessment of the medial longitudinal arch in children and adolescents with obesity: footprints and radiographic study. European journal of pediatrics. 2009;168(5):559-67.
9. da Rocha ES, Bratz DT, Gubert LC, de David A, Carpes FP. Obese children experience higher plantar pressure and lower foot sensitivity than non-obese. Clinical Biomechanics. 2014;29(7):822-7.
10. Midtbø H, Ulvik A, Cramariuc D, Meyer K, Ueland PM, Halland H, Gerdts E. Influence of cardiorespiratory fitness on obesity-associated inflammation in women and men: The FATCOR study. Nutrition, Metabolism and Cardiovascular Diseases. 2024;34(8):1942-9.
11. Ostojic SM, Stojanovic MD, Stojanovic V, Maric J, Njaradi N. Correlation between fitness and fatness in 6-14-year old Serbian school children. Journal of health, population, and nutrition. 2011;29(1):53.
12. Nordmann AJ, Nordmann A, Briel M, Keller U, Yancy WS, Brehm BJ, Bucher HC. Effects of low-carbohydrate vs low-fat diets on weight loss and cardiovascular risk factors: a meta-analysis of randomized controlled trials. Archives of internal medicine. 2006;166(3):285-93.
13. Bilim AS, Çetinkaya C, Dayı A. 12-17 yaş arasi spor yapan ve spor yapmayan öğrencilerin fiziksel uygunluklarinin incelenmesi. Spor ve Performans Araştırmaları Dergisi. 2016;7(2):53-60.
14. Ergün A, Erten SF. Öğrencilerde vücut kitle indeksi ve bel çevresi değerlerinin incelenmesi. Ankara Üniversitesi Tıp Fakültesi Mecmuası. 2004;57(2).
15. Seidell JC. Epidemiology: definition and classification of obesity. Blackwell: Malden, USA; 2005.
16. Wan CS, Ward LC, Halim J, Gow ML, Ho M, Briody JN, Leung K, Cowell CT, Garnett SP. Bioelectrical impedance analysis to estimate body composition, and change in adiposity, in overweight and obese adolescents: comparison with dual-energy x-ray absorptiometry. BMC pediatrics. 2014;14(1):249.

17. Singla D, Veqar Z. Effect of playing basketball on the posture of cervical spine in healthy collegiate students. Int J Biomed Adv Res. 2015;6(2):133-6.
18. de Oliveira TS, Candotti CT, La Torre M, Pelinson PP, Furlanetto TS, Kutchak FM, Loss JF. Validity and reproducibility of the measurements obtained using the flexicurve instrument to evaluate the angles of thoracic and lumbar curvatures of the spine in the sagittal plane. Rehabilitation research and practice. 2012;2012(1):186156.
19. Redmond AC, Crosbie J, Ouvrier RA. Development and validation of a novel rating system for scoring standing foot posture: the Foot Posture Index. Clinical biomechanics. 2006;21(1):89-98.
20. Cooper KH. A means of assessing maximal oxygen intake: correlation between field and treadmill testing. Jama. 1968;203(3):201-4.
21. Baran RT. Obez çocuk ve adolesanlarda vücut kitle indeksi ve biyoelektrik impedans yöntemi ile ölçülen vücut yağ oranının lipid düzeyleri ve metabolik parametrelerle ilişkisi. Pamukkale Medical Journal. 2018;11(3):261-7.
22. Bryant CX, Green DJ. ACE lifestyle & weight management consultant manual: the ultimate resource for fitness professionals. American Council on Exercise; 2007.
23. Aleixo AA, Guimarães EL, Walsh IA, Pereira K. Influence of overweight and obesity on posture, overall praxis and balance in schoolchildren. Journal of Human Growth and Development. 2012;22(2):239-45.
24. Fernandez-de-Las-Penas C, Alonso-Blanco C, Cuadrado ML, Pareja JA. Forward head posture and neck mobility in chronic tension-type headache: a blinded, controlled study. Cephalalgia. 2006;26(3):314-9.
25. Mandrekar S, Chavhan D, Shyam AK, Sancheti PK. Effects of carrying school bags on cervical and shoulder posture in static and dynamic conditions in adolescent students. International Journal of Adolescent Medicine and Health. 2022;34(1):20190073.
26. Shaghayeghfard B, Ahmadi A, Maroufi N, Sarrafzadeh J. Evaluation of forward head posture in sitting and standing positions. European spine journal. 2016;25(11):3577-82.
27. Bailey JF, Shefi S, Soudack M, Kramer PA, Been E. Development of pelvic incidence and lumbar lordosis in children and adolescents. The Anatomical Record. 2019;302(12):2132-9.
28. Jankowicz-Szymańska A, Bibro M, Wódka K, Smola E. Does excessive body weight change the shape of the spine in children?. Childhood Obesity. 2019;15(5):346-52.
29. Zwierzchowska A, Tuz J, Grabara M. Is BAI better than BMI in estimating the increment of lumbar lordosis for the Caucasian population?. Journal of back and musculoskeletal rehabilitation. 2020;33(5):849-55.
30. Tenenbaum S, Hershkovich O, Gordon B, Bruck N, Thein R, Derazne E, Tzur D, Shamiss A, Afek A. Flexible pes planus in adolescents: body mass index, body height, and gender—an epidemiological study. Foot & ankle international. 2013;34(6):811-7.
31. Carvalho BK, Penha PJ, Penha NL, Andrade RM, Ribeiro AP, João SM. The influence of gender and body mass index on the FPI-6 evaluated foot posture of 10-to 14-year-old school children in São Paulo, Brazil: a cross-sectional study. Journal of foot and ankle research. 2017;10(1):1.
32. Evans AM, Karimi L. The relationship between paediatric foot posture and body mass index: do heavier children really have flatter feet?. Journal of foot and ankle research. 2015;8(1):46.
33. Mondal H, Mishra SP. Effect of BMI, body fat percentage and fat free mass on maximal oxygen consumption in healthy young adults. Journal of clinical and diagnostic research: JCDR. 2017;11(6):CC17.
34. Afshari D, Rami M, Shirali GA, Azadi N. Evaluation of the Effect of Body Mass Index and Body Fat Percentage on the Maximal Oxygen Consumption: A Cross-Sectional Study. Jundishapur Journal of Health Sciences. 2019;11(2).
35. Minasian V, Marandi SM, Kelishadi R, Abolhassani H. Correlation between aerobic fitness and body composition in middle school students. International journal of preventive medicine. 2014;5(Suppl 2):S102.
36. Hayes RM, Maldonado D, Gossett T, Shepherd T, Mehta SP, Flesher SL. Developing and validating a step test of aerobic fitness among elementary school children. Physiotherapy Canada. 2019;71(2):187-94.