

Obez, Aşırı Kilolu ve Normal Kilolu Çocuklarda Fiziksel Performansın Değerlendirilmesi

Assessment of Physical Performance in Obese, Overweight and Normal-Weight Children

Gülşen TAŞKIN^{1 A,B,C,E,F,G} , Yunus Emre KUNDAKCI^{1 A,B,D,E,F,G}  Ümran ARI-CAN^{1 C,E} , Aysun ATACAN^{2 C,E}  Yiğit ŞENOL^{3 F,G} 

¹Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Afyonkarahisar Health Sciences University, Afyonkarahisar, Türkiye

²Afyonkarahisar Central Public Health Center, Afyonkarahisar, Türkiye

³Afyonkarahisar Provincial Health Directorate, Afyonkarahisar, Türkiye

ÖZ

Amaç: Çocukluk çağında aşırı kilo ve obezite, denge, çeviklik ve alt ekstremité kuvveti gibi motor performans bileşenlerinde bozulmalarla ilişkilidir. Bu çalışmada, 6–11 yaş arası ilkököl öğrencilerinde obezite düzeyleri Beden Kütle İndeksi (BKİ) ve bel/boy oranı (BBO) kullanılarak sınıflandırılmış ve bu gruplar arasında motor performans özellikleri karşılaştırılmıştır.

Yöntem: Bu kesitsel çalışmaya, bir Sağlıklı Yaşam Merkezi'ne başvuran 6–11 yaş arası (yaş ortalaması 8,61±1,32 yıl) toplam 201 ilkököl öğrencisi dahil edildi. Boy uzunluğu, vücut ağırlığı, bel ve kalça çevresi ölçülerek BKİ ve BBO hesaplandı. Çocuklar BKİ'ye göre normal kilolu, fazla kilolu ve obez olarak; BBO'ya göre abdominal obezite varlığına göre gruplandırıldı. Motor performans, tek ayak denge, çeviklik, durarak uzun atlama ve 30 saniye otur-kalk testleri ile değerlendirildi.

Bulgular: Çocukların %29,4'ü normal kilolu, %14,9'u fazla kilolu ve %55,7'si obezdi. Ayrıca çocukların %71,6'sında abdominal obezite vardı. Cinsiyete göre BKİ ve BBO açısından fark bulunmadı ($p>0,05$). BKİ ve BBO değerlerindeki artış, çeviklik süresinin uzaması ve durarak uzun atlama mesafesi ile otur-kalk tekrar sayısının azalmasıyla ilişkililiydi ($p<0,001$). Ayrıca BKİ, motor performansın anlamlı bir yordayıcısıydı ($p<0,001$).

Sonuç: Genel ve abdominal obezite özellikle çeviklik ve alt ekstremité kas gücü olmak üzere, ilkököl çağındaki çocuklarda motor performansı olumsuz etkilemektedir. Bu bulgular, ilkököl çağındaki çocuklarda obeziteyle ilişkili motor performans bozuklukları için erken tarama ve müdahale stratejilerine duyulan ihtiyacı vurgulamaktadır.

Anahtar Kelimeler: Abdominal yağlanma, Beden kütle indeksi, Bel-boy oranı, Çocukluk çağı obezitesi, Motor performans.

ABSTRACT

Objective: Childhood overweight and obesity are associated with impairments in motor performance components such as balance, agility, and lower extremity strength. This study aimed to classify obesity levels in primary school children aged 6–11 years using Body Mass Index (BMI) and waist-to-height ratio (WHtR), and to compare motor performance characteristics across these groups.

Method: This cross-sectional study included 201 primary school children aged 6–11 years (mean age: 8.61±1.32 years) who applied to a Healthy Living Center. Anthropometric measurements included height, body weight, waist and hip circumferences, from which BMI and WHtR were calculated. Children were classified as normal weight, overweight, or obese according to BMI and grouped according to the presence of abdominal obesity based on WHtR. Motor performance was assessed using standardized protocols including single-leg balance, agility, standing long jump, and the 30-second sit-to-stand test.

Sorumlu Yazar: Gülşen Taşkın

Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Afyonkarahisar Health Sciences University, Afyonkarahisar, Türkiye

gulsen.taskin@afsu.edu.tr

Geliş Tarihi: 07.12.2025 – Kabul Tarihi: 07.07.2026

Yazar Katkıları: A) Fikir/Kavram, B) Tasarım, C) Veri Toplama ve/veya İşleme, D) Analiz ve/veya Yorum, E) Literatür Taraması, F) Makale Yazımı, G) Eleştirel İnceleme

Results: Among the children, 29.4% had normal weight, 14.9% were overweight, and 55.7% were obese, and 71.6% also had abdominal obesity. No significant differences were found between sexes in terms of BMI and WHtR ($p>0.05$). Higher BMI and WHtR values were significantly associated with prolonged agility performance and decreased standing long jump distance and sit-to-stand repetitions ($p<0.001$). In addition, BMI was a significant predictor of motor performance ($p<0.001$).

Conclusion: General and abdominal obesity negatively affect motor performance in primary school children, particularly agility and lower extremity strength. These findings underline the need for early screening and intervention strategies for obesity-related motor performance impairments in primary school children.

Key words: Abdominal fat, Body mass index, Childhood obesity, Motor performance, Waist to height ratio.

1. INTRODUCTION

Obesity is widely recognised as one of the most significant global public health issues today (1). The World Health Organization (WHO) and the World Obesity Forum reported that the prevalence of childhood obesity is expected to double between 2020 and 2035 (1,2). Consequently, obesity is now regarded as a global epidemic worldwide (3), and its prevalence is also increasing in Türkiye (4). These findings highlight that the prevention and management of overweight and obesity will remain major public health priorities in the coming years.

Given that childhood obesity significantly increases the risk of chronic diseases and often persists into adulthood, regular monitoring is essential (5–7). From a public health perspective, anthropometric and physical fitness assessments are recommended for overweight and obese children (3). Although the Body Mass Index (BMI) does not take into account fat distribution in the abdominal region, it is the most widely used measure of obesity. In addition, the waist-to-hip ratio (WHtR) has become a commonly used method for identifying health risks in children (2,3,8). Systematic reviews have shown that a WHtR of 0.5 or higher is a very strong indicator of abdominal fat accumulation and heart disease (5). A longitudinal study by Hardy et al. (9) found that while BMI-based obesity rates remained stable over 30 years, WHtR ≥ 0.5 prevalence increased, suggesting WHtR is a more sensitive measure of central obesity.

Another critical issue in the fight against childhood obesity is poor motor performance in children due to increased weight (6–8). Fundamental motor skills are central to children's movement development and generally fall into three main categories: locomotor skills, object control/manipulation skills, and balance abilities (10). Studies show that locomotor skills, especially those requiring body weight support, are negatively affected by high body fat percentage (11,12). In addition, overweight or obese children show decreased coordination, balance and agility (13,14).

Assessing motor performance in primary school children using both BMI and WHtR may yield a more comprehensive understanding of how central obesity relates to motor performance. Accordingly, this study aimed to categorise obesity levels in primary school children (6 to 11 years) based on BMI and WHtR, and to compare motor performance components including single-leg balance, agility, standing long jump, and the 30-second sit-to-stand test across these categories. It was hypothesised that children with higher BMI and WHtR values would show lower motor performance compared to peers with normal BMI. The study also seeks to contribute to the limited body of research focusing on primary school children by jointly addressing BMI, WHtR and motor performance.

2. MATERIAL AND METHODS

Study Design, Setting, and Participants

This observational cross-sectional study included 201 primary school children aged 6–11 years (mean age 8.61 ± 1.32 years, male, 51.2%) who attended a Healthy Life Centre in the Aegean Region of Türkiye for a check-up with a physiotherapist and physician. The inclusion criteria encompassed two fundamental criteria: firstly, the subject must be enrolled as a student at an elementary school; secondly, they must demonstrate typical development. Children with movement disorders, mental disorders, or other illnesses reported by parents were excluded from the study. Written consent was obtained from parents and verbal consent from children after they were informed about the main objectives and potential benefits of the study. A total of 215 participants were assessed for eligibility. Five individuals failed to complete the required tests, three withdrew from the study, five had missing motor test data, and one was excluded from the analysis due to being identified as an outlier.

An a priori sample size calculation was performed using G*Power software (version 3.1) based on comparisons among BMI groups. Assuming a medium effect size ($f=0.25$), an alpha error probability of 0.05, and a statistical power of 80%, the minimum required sample size was calculated as 159 participants. Therefore, the inclusion of 201 participants was considered sufficient for the study.

The study was conducted in accordance with all relevant national regulations, institutional policies, and the principles of the Declaration of Helsinki. In this context, the necessary permissions for the study were obtained from the Afyonkarahisar Provincial Health Directorate, and ethical approval was granted by the Non-Interventional Scientific Research Ethics Committee of Afyonkarahisar Health Sciences University on June 13, 2025 (Meeting No. 2025/8, Decision No. 397).

Anthropometric Measurements

Anthropometric measurements for children were obtained using a flexible tailor's tape measure with a precision of ± 0.1 cm and a digital scale with a precision of ± 0.1 kg, in accordance with the WHO data collection protocol (2008). The measurements included height, body weight, BMI, waist circumference (WC), hip circumference (HC), waist-to-hip ratio (WHR) and WHtR. All anthropometric measurements were performed by a physiotherapist and the mean value was recorded after taking three measurements.

Hip circumference was measured at the widest part of the hips, with the tape measure held horizontally, in contact with the skin but not exerting pressure. Waist circumference was measured at the midpoint between the lower edge of the costal margin and the top of the iliac crest. The tape measure was held parallel to the ground and perpendicular to the body's long axis during normal exhalation. During the measurements, participants adopted a standing posture with their arms crossed over their opposite shoulders. BMI categories (normal weight, overweight, and obesity) were determined according to age- and sex-specific BMI percentile values developed for Turkish children by Neyzi et al. (15). Additionally, abdominal obesity was defined using a WHtR cut-off value of ≥ 0.4741 , which has been previously validated for Turkish children by Kılınç et al. (16) (Figure 1).

The Measurement of Motor Performance

The children's motor performance was assessed by a researcher physiotherapist using a series of tests designed to evaluate single-leg balance, agility, standing long jump and 30-second sit-to-stand. During the experimental phase, the children were attired in comfortable clothing and sports shoes that they would wear in their daily lives and which would not restrict their movements. A two-minute break was scheduled between each assessment to mitigate the impact of fatigue.

Single-Leg Balance Test: This test was used to assess static balance. During the test, children were asked to stand on one leg and bring the other leg into a 90-degree flexed position while crossing their upper limbs over their torso. The duration for which they remained in this position was recorded in seconds (17).

Agility Test: This test was used to assess children's agility. In the test, the child was asked to move from a supine position to an upright position (3.05 m), pick up a tennis ball on the ground, and return to the initial supine position. The time taken to complete this movement was recorded in seconds (18). The start and end points were determined, and the children were given a trial run. After a short rest period, the children were in the supine position when the "Start" command was given to start the timer, and the time was recorded when the children picked up the tennis ball and returned to the supine position (19).

Standing Long Jump Test: This test is a highly practical, time-efficient and inexpensive method of assessing children's muscle strength. During the test, children are instructed to stand with their feet together at the starting line, with their knees bent and their toes behind the line. They then push off with their legs and swing their arms forward in an attempt to jump as far as possible horizontally. The distance between the starting line and the point at which their toes finally touch is recorded in metres (17).

30-second sit-to-stand test: This test evaluates children's motor performance and strength in their lower extremities. The test was performed using a 46 cm high chair without armrests. The chair was secured against the wall. The children sat on the chair with their feet flat on the floor and their arms crossed over their chest. They then stood up with their knees fully extended and sat back down, ensuring their pelvis was in contact with the chair. The number of successful sit-to-stand cycles was recorded after 30 seconds (20).

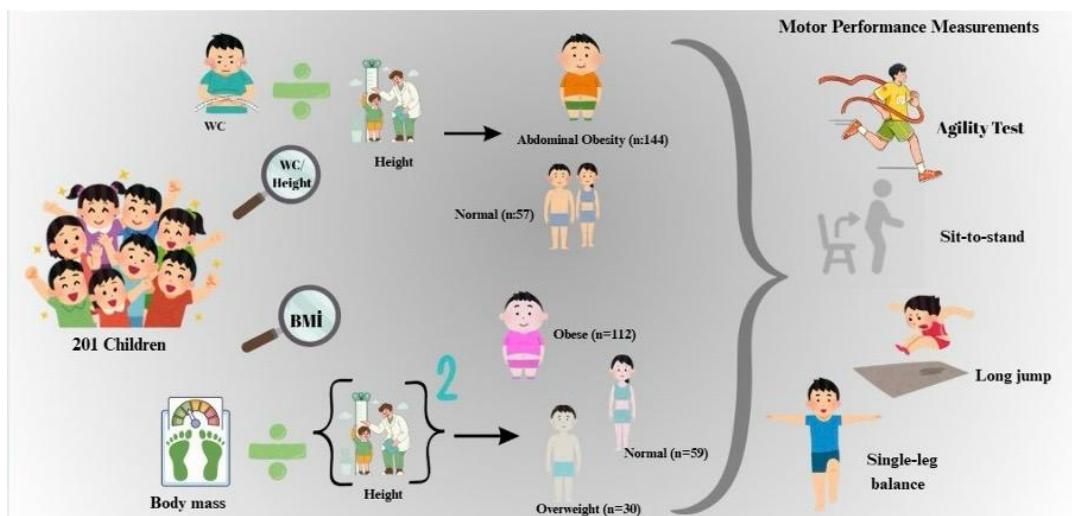


Figure 1. Data collection protocol in the study

Statistical Analysis

The data were analysed using SPSS version 25. Normality was assessed with the Shapiro–Wilk test. Variables with normal distribution were presented as mean±standard deviation (Mean±SD), and non-normal variables as median (interquartile range, IQR). To compare BMI groups, one-way ANOVA was used for normally distributed variables, while the Kruskal–Wallis test was applied for non-normal data. For normally distributed variables (height, hip circumference, and standing long jump), one-way ANOVA followed by Tukey HSD post-hoc analysis was used. For non-normally distributed variables, Kruskal–Wallis analysis followed by Bonferroni-corrected pairwise comparisons was performed. Statistical significance for post-hoc comparisons was set at $p < 0.017$ ($0.05/3 = 0.017$). A WHtR cut-off of 0.4741 was used to define abdominal obesity (present/absent). Group differences were examined with the Mann–Whitney U test, and relationships between BMI, WHtR and gender were assessed using the chi-square test. Associations between motor performance and anthropometric measures were analysed with Spearman’s correlation. Correlation coefficients of 0.00–0.19 were considered negligible, 0.20–0.39 weak, 0.40–0.69 moderate, 0.70–0.89 strong, and 0.90–1.00 very strong. Predictors of motor performance were examined using linear regression analyses, with BMI, WHtR and gender as independent variables. Statistical significance was set at $p < 0.05$.

3. RESULTS

The study comprised 201 participants (103 males, 51.2%; 98 females, 48.8%) with a mean age of 8.61 ± 1.32 years. The BMI values of the participants were as follows: 29.4% were of normal weight, 14.9% were overweight, and 55.7% were obese. According to WHtR-based classification of central obesity, 144 (71.6%) of the subjects had abdominal obesity. The descriptive characteristics of the participants are presented in Table 1. There was no significant difference in BMI ($\chi^2 = 0.976$; $p = 0.614$) and WHtR ($\chi^2 = 0.143$; $p = 0.705$; Fisher’s Exact $p = 0.755$) between girls and boys (Figure 2).

Table 1. Demographic Characteristics of the Participants (N= 201).

Variables	Mean±SD	Median (IQR)
Age (years)	8.61±1.32	8.58 (2.00)
Height (cm)	135.16±9.94	135.00 (14.00)
Body mass (kg)	39.49±11.37	39.20 (52.60)
BMI (kg/m ²)	21.26±4.30	21.08 (6.11)
WC (cm)	68.61±8.81	68.00 (12.50)
HC (cm)	80.53±9.67	80.00 (13.50)
WHR	0.85±0.05	0.85 (0.06)
WHtR	0.51±0.05	0.51 (0.07)
Variables	N (%)	
Gender	Boys: 103 (51.2%)	
	Girls: 98 (48.8%)	
BMI categories	Normal: 59 (29.4%)	
	Overweight: 30 (14.9%)	
	Obese: 112 (55.7%)	
WHtR categories	WHtR < 0.4741: 57 (28.4%)	
	WHtR ≥ 0.4741: 144 (71.6%)	

BMI = body mass index, HC= hip circumference, IQR= interquartile range, N= frequency, SD= standard deviation, WC = waist circumference, WHR= waist-to-hip ratio, WHtR = waist-to-height ratio.

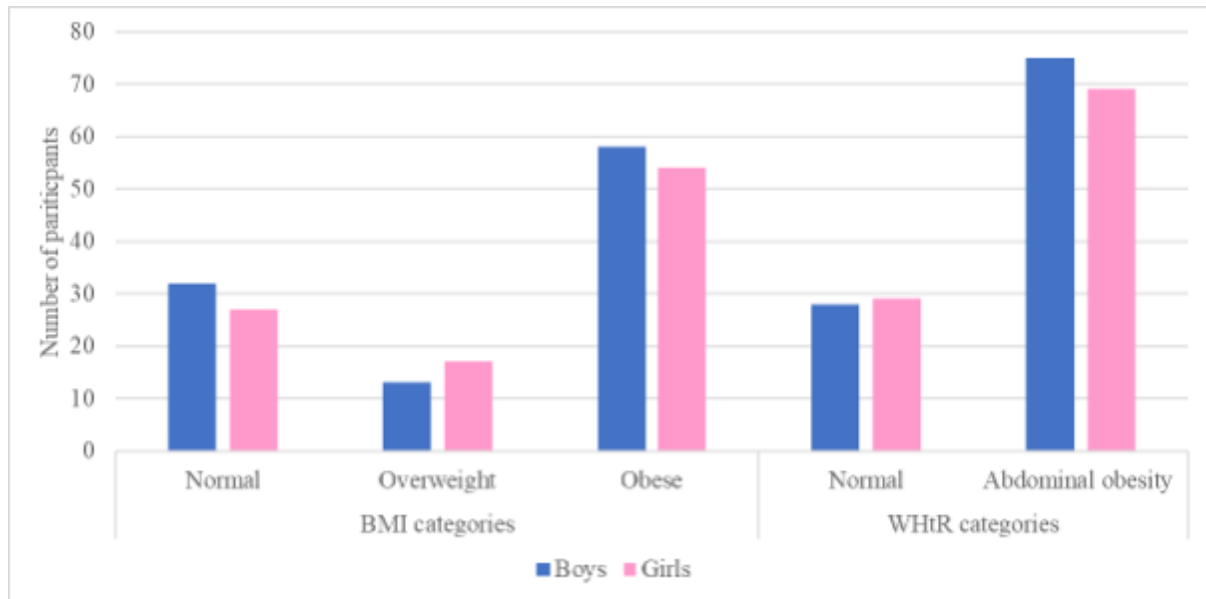


Figure 2. Distribution of BMI and WHtR categories by gender.

Comparison of Anthropometric Characteristics and Motor Performance with BMI Categories

Table 2. Participants' Anthropometric Measurements and Motor Characteristics According to BMI Categories.

Variables	Normal (N=59)	Overweight (N=30)	Obese (N=112)	Test Statistic	Overall p	Normal vs Overweight	Normal vs Obese	Overweight vs Obese
Age (years)	9.00 (2.00)	8.25 (2.00)	8.33 (2.00)	$\chi^2=5.557$	0.062	–	–	–
Height (cm)	133.59±11.62	133.36±10.07	136.47±8.78	F=2.229	0.110	–	–	–
Body mass (kg)	27.00 (12.00)	33.85 (8.30)	44.00 (14.80)	$\chi^2=87.978$	<0.001	0.045	<0.001	<0.001
BMI (kg/m ²)	16.00 (3.19)	19.52 (1.61)	24.13 (4.10)	$\chi^2=145.926$	<0.001	0.002	<0.001	<0.001
WC (cm)	61.00 (8.00)	65.50 (8.25)	73.00 (10.38)	$\chi^2=79.565$	<0.001	0.137	<0.001	<0.001
HC (cm)	72.51±8.09	77.87±6.54	85.46±11.38	F=55.814	<0.001	0.007	<0.001	<0.001
WHR	0.85 (0.06)	0.85 (0.07)	0.85 (0.06)	$\chi^2=2.011$	0.366	–	–	–
WHtR	0.46 (0.04)	0.49 (0.04)	0.53 (0.06)	$\chi^2=92.515$	<0.001	0.042	<0.001	<0.001
Right single-leg balance (s)	44.49 (41.30)	31.28 (42.08)	26.83 (48.15)	$\chi^2=4.074$	0.130	–	–	–
Left single-leg balance (s)	40.60 (55.50)	31.59 (44.61)	25.72 (46.11)	$\chi^2=4.245$	0.120	–	–	–
Agility (s)	6.00 (1.51)	8.47 (2.35)	8.70 (1.82)	$\chi^2=85.469$	<0.001	<0.001	<0.001	0.604
Standing long jump (cm)	140.95±30.18	99.60±26.24	85.76±24.00	F=103.238	<0.001	<0.001	<0.001	0.015
30-second sit-to-stand	23.00 (5.00)	19.00 (6.75)	17.00 (5.75)	$\chi^2=50.473$	<0.001	0.873	<0.001	<0.001

BMI = body mass index; HC = hip circumference; N = frequency; WC = waist circumference; WHR = waist-to-hip ratio; WHtR = waist-to-height ratio. Values are presented as mean±standard deviation for normally distributed variables and median (interquartile range) for non-normally distributed variables. Group differences were tested using one-way ANOVA (F) for normally distributed variables and the Kruskal–Wallis test (χ^2) for non-normally distributed variables. Pairwise post-hoc comparisons are presented separately for Normal vs. Overweight, Normal vs. Obese, and Overweight vs. Obese groups. Statistical significance for post-hoc comparisons was set at $p<0.017$ following Bonferroni correction. Values >0.017 were considered non-significant.

There was no significant difference between the groups in terms of age, height, and WHR among normal, overweight, and obese children (Table 2). Significant differences were

observed in body weight, BMI, waist circumference, hip circumference, and WHtR. In Bonferroni-corrected post-hoc comparisons, body weight was higher in obese children than in both normal and overweight groups, while the difference between normal and overweight groups was not significant. Obese children had significantly higher waist and hip circumferences, and WHtR than normal-weight and overweight peers ($p < 0.001$ for all) (Table 2).

Regarding motor performance, no significant differences were found in right or left single-leg balance. However, significant group differences were found in agility, long jump, and sit-to-stand tests. Specifically, higher obesity levels were progressively associated with longer agility times, shorter long jump distances, and poorer sit-to-stand performance. These findings, summarised in Table 2, provide a comprehensive comparison of BMI categories.

Comparison of Anthropometric Characteristics and Motor Performance with Whtr Categories

Table 3. Participants' Motor Characteristics According to Abdominal Obesity Categories.

Variables	Abdominal obesity absent (N=57)	Abdominal obesity present (N=144)	Test Statistic	
	Median (IQR)	Median (IQR)	U	<i>P-value</i>
Age (years)	8.83 (2.00)	8.42 (2.00)	3523.5	0.117
BMI (kg/m ²)	16.65 (4.92)	22.63 (5.13)	7314.5	<0.001
WHtR (WC/Height)	0.46 (0.03)	0.52 (0.06)	8208	<0.001
Right single-leg balance (s)	44.29 (46.80)	26.98 (46.75)	3429.5	0.070
Left single-leg balance (s)	40.76 (53.32)	25.89 (46.11)	3158.5	0.011
Agility (s)	6.07 (1.63)	8.53 (2.08)	7080.5	<0.001
Standing long jump (cm)	138.00 (49.50)	89.00 (30.75)	1230.5	<0.001
30-second sit-to-stand	21.00 (7.00)	18.00 (6.00)	2635.5	<0.001

BMI = body mass index; IQR = interquartile range; N = frequency; WC=waist circumference; WHtR = waist-to-height ratio. Abdominal obesity absent was defined as WHtR < 0.4741, and abdominal obesity present as WHtR ≥ 0.4741. Values are presented as Median (IQR). Group differences were analyzed using the Mann–Whitney U test.

BMI values of children with abdominal obesity were significantly higher than those of the normal group. No significant difference was found between groups in terms of age. In motor performance tests, there was no significant difference in standing time on the right foot, while standing time on the left foot was shorter in children with abdominal obesity. Additionally, these children showed longer agility times, shorter long jump distances and fewer sit-to-stand repetitions (Table 3).

Correlations between BMI, Abdominal Obesity and Motor Performance

As BMI category increased from normal to obese, the presence of abdominal obesity became more evident (Table 4). BMI was negatively correlated with left single-leg standing time, while WHtR was negatively correlated with standing time on both feet. Higher BMI was associated with longer agility times and poorer performance in the standing long jump and 30-second sit-to-stand test. Similarly, WHtR showed a positive correlation with agility time and negative correlations with standing long jump distance and sit-to-stand repetitions. Overall,

these findings indicate moderate to strong correlations between adiposity indicators (BMI and WHtR) and motor performance outcomes.

Table 4. χ^2 Analysis of the Association Between BMI Categories and Abdominal Obesity (WHtR).

BMI categories	WHtR categories		χ^2 test	p -value
	Abdominal obesity absent (N=57)	Abdominal obesity present (N=144)		
	N (%)	N (%)	χ^2	
Normal (N=59)	41 (69.5)	18 (30.5)	78.666	<0.001
Overweight (N=30)	10 (33.3)	20 (66.7)		
Obese (N=112)	6 (5.4)	106 (94.6)		

%= percentage; BMI = body mass index, χ^2 = chi squared statistic; WHR= waist-to-hip ratio, WHtR = waist-to-height ratio; N= frequency.

Regression Analysis

Table 5. Regression analysis of relationships between BMI and WHtR and motor performance tests (N=201).

Dependent Variable	Predictor	B (Estimate)	SE	β (Stand.)	t	p	95% CI (Lower–Upper)
Right single-leg balance (s)	WHtR	-94.7	67.45	-0.096	-1.40	0.162	-0.230 – 0.039
	Gender (B–G)	-27.4	7.10	-0.526	-3.87	<0.001	-0.795 – -0.258
Left single-leg balance (s)	WHtR	-142.3	105.8	-0.144	-1.35	0.180	-0.356 – 0.067
	BMI	0.27	1.30	0.022	0.21	0.835	-0.189 – 0.234
	Gender (B–G)	-0.85	7.34	-0.016	-0.12	0.908	-0.295 – 0.262
Agility (s)	WHtR	4.15	3.22	0.110	1.29	0.200	-0.059 – 0.278
	BMI	0.229	0.040	0.494	5.79	<0.001	0.326 – 0.662
	Gender (B–G)	-0.899	0.224	-0.451	-4.02	<0.001	-0.673 – -0.230
Standing long jump (cm)	WHtR	-95.4	54.5	-0.148	-1.75	0.082	-0.314 – 0.019
	BMI	-3.93	0.669	-0.496	-5.88	<0.001	-0.663 – -0.330
	Gender (B–G)	9.61	3.78	0.282	2.54	0.012	0.063 – 0.501
30-second sit-to-stand	WHtR	2.77	8.51	0.030	0.33	0.745	-0.154 – 0.214
	BMI	-0.595	0.104	-0.531	-5.70	<0.001	-0.715 – -0.347
	Gender (B–G)	0.032	0.590	0.007	0.05	0.957	-0.235 – 0.248

Significant results are shown in bold ($p < 0.05$). B = unstandardized coefficient; SE = standard error; β = standardized coefficient; CI = confidence intervals for the standardized regression coefficients (β); B–G = Boy–Girl WHtR and BMI were included as covariates, and gender as a categorical variable in the analysis. Adjusted R^2 values: Agility = 0.440; Long jump = 0.542; Sit-to-stand test = 0.215; Right single-leg stance = 0.072; Left single-leg stance = 0.002.

Multiple linear regression analyses (Table 5) revealed that BMI and gender significantly influenced motor performance. BMI and gender together explained 44% of agility variance, 54% of long jump variance, and 22% of sit-to-stand variance. Higher BMI predicted slower agility performance, shorter long jump distance, and fewer sit-to-stand repetitions. In addition, gender differences were observed in balance, agility, and long jump performance.

4. DISCUSSION

In this study, more than half of the children were classified as obese according to BMI, and abdominal obesity was present in the majority of participants based on WHtR. In addition,

higher BMI and WHtR values were associated with poorer motor performance outcomes, particularly in agility, standing long jump, and sit-to-stand tests. On the other hand, BMI was found to be a significant predictor of motor performance tests and explained a substantial portion of the variation in performance. Although WHtR was associated with various motor performance parameters, it was not identified as an independent predictor in regression analyses. BMI showed a more consistent relationship with motor performance outcomes than WHtR.

Previous studies have consistently demonstrated an association between childhood obesity and lower motor performance, particularly in tasks requiring speed, coordination, and muscular power (21–23). Similarly, our findings showed that higher BMI values were associated with poorer agility and standing long jump performance (24–27). Excess body mass may increase the mechanical demands of movement and reduce efficiency during motor tasks (28). However, because of the cross-sectional design, these findings should be interpreted as correlational rather than causal. In the present study, BMI showed a more consistent relationship with motor performance than WHtR. Although previous studies from Chile and China reported associations between higher WHtR values and lower strength, agility, and cardiorespiratory fitness (29,30), WHtR was not identified as an independent predictor in the regression analyses. These differences may be related to variations in age, fitness components tested, or population characteristics.

Another important finding was that, although standing times on both feet did not differ significantly across BMI categories, children with abdominal obesity had shorter standing times on the left foot according to WHtR. WHtR was also negatively correlated with balance performance. Previous studies have similarly reported that excess fat mass may impair postural control and balance performance in children (24,31).

The current findings also highlight gender differences in motor performance. Regression analysis revealed that girls displayed superior balance, whereas boys showed better agility. Previous studies have highlighted gender-specific differences in motor skills. These studies, in particular, reported differences in muscle strength, coordination, and maturation, which may partially explain the current findings (11–13). Chen et al. (39) reported a U-shaped relationship between BMI and physical fitness, with stronger effects in boys, supporting the notion that growth and developmental factors influence motor performance differently by gender (12–14). Compared with BMI, WHtR may provide practical advantages in pediatric obesity screening because it is easier to interpret and can be applied using a simple cut-off value. Recent studies have shown that WHtR is useful for identifying abdominal obesity and cardiometabolic risk factors in children and adolescents (32,33). The combined use of BMI and WHtR may therefore provide a broader evaluation of obesity-related health risks in childhood.

Furthermore, current evidence suggests that incorporating waist-related measurements into school obesity surveillance programs may improve early identification of children at risk for future metabolic and cardiovascular complications (34). In this context, integrating WHtR alongside BMI measurements may also help identify children who are at greater risk for reduced motor performance and physical fitness, thereby supporting the implementation of targeted physical activity, physiotherapy, and obesity prevention strategies in school and community settings.

The present study has some limitations. The sample was restricted to a specific age range and region, and participants were recruited from a healthy life centre, possibly increasing obesity prevalence relative to the general population. Another limitation of the present study is that physical activity levels were not assessed. Since habitual physical activity may influence both adiposity and motor performance, the absence of objective or questionnaire-based physical activity measurements may have limited the interpretation of the observed associations. Physical activity level, prior sports participation, dietary habits, and socioeconomic status were not controlled for. Future studies incorporating these variables could better explain causality. From a clinical standpoint, the findings reinforce the importance of monitoring both general and abdominal adiposity from early childhood, as reduced motor performance may discourage physical activity over time. Another limitation of the study is that motor performance tests were performed only once to minimize fatigue and maintain children's cooperation. Repeated trials might have improved measurement reliability. Despite these limitations, a strength of the study was the combined evaluation of BMI and WHtR together with multiple motor performance components in primary school children. Furthermore, the use of simple and practical anthropometric measurements may increase the applicability of the findings in school-based screening settings.

5. CONCLUSION

This study demonstrated a significant association between obesity and reduced motor performance in primary school children. Increased body fat was associated with poorer agility, reduced jumping performance, and lower sit-to-stand performance. The relationship between BMI and motor performance was stronger than that between WHtR and motor performance. Routine assessment of BMI and basic motor performance tests in primary schools may help identify children who require early support to prevent long-term physical inactivity and related health problems.

Ethical Considerations

This study adhered to the principles of the Declaration of Helsinki. Ethical approval was obtained from the Non-Interventional Scientific Research Ethics Committee of Afyonkarahisar Health Sciences University prior to the commencement of the study (Date: June 13, 2025; Meeting No: 2025/8; Decision No: 397). Permission to conduct the study was also obtained from the Afyonkarahisar Provincial Health Directorate. All participants provided written informed consent prior to participation.

Conflict of Interest

The authors declare no conflicts of interest with the research or writing of this paper.

REFERENCES

1. World Health Organization. (2025). Obesity and overweight. Available from: <https://www.who.int/news-room/fact-sheets/obesity-and-overweight>.
2. World Obesity Federation. (2023). World Obesity Atlas. Available from: <https://data.worldobesity.org/publications/?cat=19>
3. Ahmed, S. K., & Mohammed, R. A. (2025). Obesity: Prevalence, causes, consequences,

- management, preventive strategies and future research directions. *Metab Open*, 27, 100375. <https://doi.org/10.1016/j.metop.2025.100375>
4. Nevill, A. M., Brand, C., Chen, R., Duncan, M. J., de C Silveira, J. F., Sehn, A. P., et al. (2025). NICE waist-to-height ratio guidelines “to have a waist < 0.5 of your hight”, are suitable for children but misleading for adolescents. *Nutr, Metab and Cardiovasc Dis*, 35(10), 104117. <https://doi.org/10.1016/j.numecd.2025.104117>
 5. Llewellyn, A., Simmonds, M., Owen, C. G., & Woolacott, N. (2016). Childhood obesity as a predictor of morbidity in adulthood: A systematic review and meta-analysis. *Obes Rev*, 17(1), 56–67. <https://doi.org/10.1111/obr.12316>
 6. Mitchell, L., Bel-Serrat, S., Heinen, M., Mehegan, J., Murrin, C., O’Brien, S., et al. (2021). Waist circumference-to-height ratio and body mass index for obesity classification in Irish children. *Acta Paediatr*, 110(5), 1541–1547. <https://doi.org/10.1111/apa.15724>
 7. Caprio, S., Santoro, N., & Weiss, R. (2020). Childhood obesity and the associated rise in cardiometabolic complications. *Nat Metab*, 2(3), 223–232. <https://doi.org/10.1038/s42255-020-0183-z>
 8. Ministry of Health, General Directorate of Public Health. (2022). Turkey Childhood Obesity Surveillance Initiative–COSI-TUR. Available from https://hsgm.saglik.gov.tr/depo/birimler/saglikli-beslenme-ve-hareketli-hayatdb/Dokumanlar/Kitaplar/Turkiye_Cocukluk_Cagi_Obezite_Arastirmasi_2022.pdf
 9. Hardy, L.L., Miharshahi, S., Gale, J., Drayton, B.A., Bauman, A., & Mitchell, J. (2017). 30-year trends in overweight, obesity and waist-to-height ratio by socioeconomic status in Australian children, 1985 to 2015. *Int J Obes*, 41(1):76–82.
 10. Ashwell. M., & Hsieh, S.D. (2005). Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. *Int J Food Sci Nutr*. Jan 6;56(5):303–7 <https://doi.org/10.1080/09637480500195066>
 11. Webster, E. K., Sur, I., Stevens, A., & Robinson, L. E. (2021). Associations between body composition and fundamental motor skill competency in children. *BMC Pediatr*, 21(1), 444. <https://doi.org/10.1186/s12887-021-02912-9>
 12. Morrison, K. M., Cairney, J., Eisenmann, J., Pfeiffer, K., & Gould, D. (2018). Associations of Body Mass Index, Motor Performance, and Perceived Athletic Competence with physical activity in normal weight and overweight children. *J Obes*, 2018, 1–10. <https://doi.org/10.1155/2018/3598321>
 13. Barros, W. M. A., Silva, K. G. da, Silva, R. K. P., Souza, A. P. da S., Silva, A. B. J. da, Silva, M. R. M., et al. (2022). Effects of overweight/obesity on motor performance in children: a systematic review. *Front Endocrinol*, 12. <https://doi.org/10.3389/fendo.2021.759165>
 14. Allisse, M., Thibault, I., Gagnon, D., Kalinova, E., Larivière, G., & Leone, M. (2025). The relationship between obesity status and body image dissatisfaction on gross motor skill development and cardiorespiratory fitness in children aged 6–12 years old. *Int J Environ Res Public Health*, 22(3), 417. <https://doi.org/10.3390/ijerph22030417>
 15. Neyzi, O., Günöz, H., Bundak, R., & Gokcay, G. (2008). Body weight, height, head

- circumference and body mass index reference values in Turkish children. Available from <https://www.researchgate.net/publication/255622491>
16. Kılınç, A., Çöl, N., Demircioğlu-Kılıç, B., Aydın, N., Balat, A., & Keskin, M. (2019). Waist to height ratio as a screening tool for identifying childhood obesity and associated factors. *Pak J Med Sci*, 35(6). <https://doi.org/10.12669/pjms.35.6.748>
17. Martone, A. M., Levati, E., Ciciariello, F., Galluzzo, V., Salini, S., Calvani, R., et al. (2025). Impact of waist-to-hip and waist-to-height ratios on physical performance: insights from the Longevity Check-up 8+ project. *Aging*. <https://doi.org/10.18632/aging.206260>
18. Ashwell, M., & Gibson, S. (2016). Waist-to-height ratio as an indicator of ‘early health risk’: simpler and more predictive than using a ‘matrix’ based on BMI and waist circumference. *BMJ Open*, 6(3), e010159. <https://doi.org/10.1136/bmjopen-2015-010159>
19. Hardy, L.L., Miharshahi, S., Gale, J., Drayton, B.A., Bauman, A., & Mitchell, J. (2017). 30-year trends in overweight, obesity and waist-to-height ratio by socioeconomic status in Australian children, 1985 to 2015. *Int J Obes*, 41(1):76–82.
20. Raistenskis, J., Sidlauskienė, A., Struckinskiene, B., Uğur Baysal, S., & Buckus, R. (2016). Physical activity and physical fitness in obese, overweight, and normal-weight children. *Turk J Med Sci*, 46, 443–450. <https://doi.org/10.3906/sag-1411-119>
21. Gil Madrona, P., Romero Martínez, S. J., Sáez-Gallego, N. M., & Ordóñez Camacho, X. G. (2019). Psychomotor limitations of overweight and obese five-year-old children: influence of body mass indices on motor, perceptual, and social-emotional skills. *Int J Environ Res Public Health*, 16(3), 427. <https://doi.org/10.3390/ijerph16030427>
22. Cairney, J., Hay, J. A., Faught, B. E., & Hawes, R. (2005). Developmental coordination disorder and overweight and obesity in children aged 9–14 y. *International J Obes*, 29(4), 369–372. <https://doi.org/10.1038/sj.ijo.0802893>
23. Marmeleira, J., Veiga, G., Cansado, H., & Raimundo, A. (2017). Relationship between motor proficiency and body composition in 6- to 10-year-old children. *J Paediatr Child Health*, 53(4), 348–353. <https://doi.org/10.1111/jpc.13446>
24. Cattuzzo, M. T., dos Santos Henrique, R., Ré, A. H. N., de Oliveira, I. S., Melo, B. M., de Sousa Moura, M., et al. (2016). Motor competence and health related physical fitness in youth: A systematic review. *J Sci and Med Sport*, 19(2), 123–129. <https://doi.org/10.1016/j.jsams.2014.12.004>
25. D’Hondt, E., Deforche, B., Gentier, I., De Bourdeaudhuij, I., Vaeyens, R., Philippaerts, R., et al. (2013). A longitudinal analysis of gross motor coordination in overweight and obese children versus normal-weight peers. *Int J Obes*, 37(1), 61–67. <https://doi.org/10.1038/ijo.2012.55>
26. Haapala, E. A., Väistö, J., Lintu, N., Tompuri, T., Brage, S., Westgate, K., et al. (2016). Adiposity, physical activity and neuromuscular performance in children. *J Sports Sci*, 34(18), 1699–1706. <https://doi.org/10.1080/02640414.2015.1134805>
27. Baldinger, N., Krebs, A., Müller, R., & Aeberli, I. (2012). Swiss children consuming breakfast regularly have better motor functional skills and are less overweight than breakfast skippers. *J Am Coll Nutr*, 31(2), 87–93. <https://doi.org/10.1080/07315724.2012.10720013>
28. Vega-Ramirez, L., Pérez-Cañaveras, R. M., & De Juan Herrero, J. (2021). There is an

- inverse correlation between basic motor skills and overweight in schoolchildren aged 8 to 12. *Children*, 8(12), 1198. <https://doi.org/10.3390/children8121198>
29. Albornoz-Guerrero, J., Carrasco-Marín, F., Zapata-Lamana, R., Cigarroa, I., Reyes-Molina, D., Barceló, O., et al. (2022). Association of physical fitness, screen time, and sleep hygiene according to the waist-to-height ratio in children and adolescents from the extreme south of chile. *Healthcare*, 10(4), 627. <https://doi.org/10.3390/healthcare10040627>
30. Guo, J., Lu, Z., Bao, Y., Chang, J., Zhang, H., Wang, F., et al. (2025). Physical fitness is associated with fat mass and muscle mass in Chinese preschoolers. *BMC Public Health*, 25(1), 2304. <https://doi.org/10.1186/s12889-025-23406-8>
31. Barnett, L. M., van Beurden, E., Morgan, P. J., Brooks, L. O., Zask, A., & Beard, J. R. (2009). Six year follow-up of students who participated in a school-based physical activity intervention: a longitudinal cohort study. *Int J Behav Nutr and Phys Act*, 6(1), 48. <https://doi.org/10.1186/1479-5868-6-48>
32. Jiang, Y., Dou, Y., Chen, H., Zhang, Y., Chen, X., Wang, Y., et al. (2021). Performance of waist-to-height ratio as a screening tool for identifying cardiometabolic risk in children: a meta-analysis. *Diabetology & Metabolic Syndrome*, 13(1):66. <https://doi.org/10.1186/s13098-021-00688-7>
33. Eslami, M., Pourghazi, F., Khazdouz, M., Tian, J., Pourrostami, K., Esmacili-Abdar, Z., et al. (2023). Optimal cut-off value of waist circumference-to-height ratio to predict central obesity in children and adolescents: A systematic review and meta-analysis of diagnostic studies. *Front Nutr*. 9:985319. <https://doi.org/10.3389/fnut.2022.985319>
34. Kula, A., Brender, R., Bernartz, K.M., Walter, U. (2024). Waist circumference as a parameter in school-based interventions to prevent overweight and obesity-a systematic review and meta-analysis. *BMC Public Health* 17;24(1):2864. <https://doi.org/10.1186/s12889-024-20354-7>