Original Article

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# Effect of Body Mass Index on Balance, Trunk Muscle Endurance, Functional Mobility and, Physical Activity in College Students

## Üniversite Öğrencilerinde Vücut Kitle İndeksinin Denge, Gövde Kas Enduransı, Fonksiyonel Mobilite ve Fiziksel Aktivite Düzeyine Etkisi

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## ABSTRACT

**Objective:** The increasing prevalence of obesity at all ages in recent years also increases the need for physiotherapy and rehabilitation. Obesity can negatively affect physical fitness and college students are prone to obesity due to stress and anxiety they experience during their university years. This study aims to investigate the effect of body mass index (BMI) on balance, trunk muscle endurance, functional mobility, and physical activity in college students.

**Methods:** College students were divided into four groups according to BMI values: underweight, normal, overweight and obese. Balance was assessed using biodex balance system, trunk muscle endurance was measured through Biering-Sorensen and McGill trunk flexor endurance tests, functional mobility was evaluated with 30-second sit-to-stand test, and physical activity determined using International Physical Activity Questionnaire-Short Form.

**Results:** The study included 73 college students (mean= 20.76±1.11 years, 72.6% women). Normal weight students were significantly better than obese students regarding trunk muscle endurance scores ($p<0.01$). Obese students spent significantly more time sitting than underweight students ($p<0.05$). No significant correlation was found between BMI and balance and functional mobility ($p>0.05$).

**Conclusion:** Increased BMI can negatively affect trunk muscle endurance and sitting time. Exercises to improve trunk muscle

## ÖZ

**Amaç:** Son yıllarda obezitenin her yaşta görülme sıklığının artması, fizyoterapi ve rehabilitasyona olan ihtiyacı artırmaktadır. Obezite fiziksel uygunluğu olumsuz yönde etkileyebilmektedir ve üniversite öğrencileri, üniversite yıllarında yaşadıkları stres ve kaygı nedeniyle obeziteye yatkın hale gelmektedir. Bu çalışma, üniversite öğrencilerinde vücut kitle indeksinin (VKİ) denge, gövde kas enduransı, fonksiyonel mobilite ve fiziksel aktivite üzerine etkisini araştırmayı amaçlamaktadır.

**Yöntemler:** Üniversite öğrencileri VKİ değerlerine göre zayıf, normal kilolu, hafif kilolu ve obez olmak üzere dört gruba ayrıldı. Denge, Biodex Denge Sistemi ile; gövde kas enduransı, Biering-Sorensen ve McGill gövde fleksör endurans testleri ile; fonksiyonel mobilite, 30 saniye otur-kalk testi ile; fiziksel aktivite, Uluslararası Fiziksel Aktivite Anketi-Kısa Form kullanılarak değerlendirildi.

**Bulgular:** Çalışmaya 73 üniversite öğrencisi dahil edildi (ortalama yaş= 20,76±1,11 yıl, %72,6 kadın). Normal kilolu öğrencilerin gövde kas endurans skorları obez öğrencilere göre anlamlı düzeyde daha iyiydi ($p<0,01$). Obez öğrenciler, zayıf öğrencilere göre oturarak anlamlı olarak daha fazla zaman harcıyorlardı ($p<0,05$). VKİ ile denge ve fonksiyonel mobilite arasında anlamlı bir ilişki bulunamadı ($p>0,05$).

**Sonuç:** Artan VKİ gövde kas enduransını ve oturma süresini olumsuz yönde etkileyebilir. Obez öğrencilerin fizyoterapi ve

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**ABSTRACT**

endurance should be added to the physiotherapy and rehabilitation programs of obese students. Therefore, it is important for universities to adopt an approach that supports exercise habits and physical activity to prevent obesity.

**Keywords:** Young adults, university students, obesity, body composition

**ÖZ**

rehabilitasyon programlarına gövde kas enduransını geliştirmeye yönelik egzersizler eklenmelidir. Bu nedenle üniversitelerin obeziteyi önlemek için egzersiz alışkanlığını ve fiziksel aktiviteyi destekleyen bir yaklaşım benimsemesi önemlidir.

**Anahtar Kelimeler:** Genç yetişkinler, üniversite öğrencileri, obezite, vücut kompozisyonu

## Introduction

Obesity is defined as excessive accumulation of adipose tissue in the human body at a level that threatens health (1). As a result of imbalances in calorie exchange, genetic and environmental factors, calorie intake is greater than calorie burned, resulting in a tendency to weight gain and the development of obesity (2). With the effect of increasing technology use and sedentary lifestyle, there is an enhance in the prevalence of obesity and weight gain problems (3). As the prevalence of obesity raises, the frequency of obesity-related diseases also increases. Obesity is associated with diseases that concern a wide range of systems, such as metabolic-hormonal complications, cardiovascular system diseases, respiratory system diseases, digestive system diseases, and musculoskeletal system diseases (4).

Obese individuals may face challenges in maintaining balance. Obesity changes body structure, enhances the mass of distinct body segments, and can result in biomechanical complications. In obese individuals, the abnormal distribution of body fat changes the center of gravity, resulting in a decrease in control of balance (5). Especially anthropometric measurements such as height and weight significantly affect both postural sway and postural stability (6).

Obesity not only impacts metabolism but also profoundly affects musculoskeletal health. Excessive adiposity leads to compromised skeletal muscle function, diminishing strength and muscle endurance due to metabolic dysregulation and inflammation (7). Additionally, obesity alters gait kinetics and kinematics, resulting in deviations from normal walking patterns and increased risk of injury. The mechanical burden of excess weight can also lead to postural abnormalities and malalignments, exacerbating functional impairment. Overall, the multifaceted effects of obesity extend beyond metabolic dysfunction to encompass significant challenges to musculoskeletal integrity and functional mobility (8).

University years are especially important times in shaping physical activity, diet and lifestyle habits (9). Young adults are prone to gaining weight during college years due to increased stress and anxiety levels (10). It has been stated that college students gain weight, especially in the first year of university (11). College students may face depression and anxiety due to reasons such as academic performance, pressure to be succeed, and post-graduation plans (12). As life expectancy is expected to continue to increase in all regions of the world, healthy aging becomes more important day by day (13). Since exercise habits and healthy dietary can prevent obesity, it is important to acquire healthy nutrition and physical activity habits at an early age during the healthy aging process (14). Because obesity, which occurs in youth and adolescence, tends to progress in later ages (15). Therefore, obesity is an important public health problem that occurs worldwide as a disease of all ages (16).

Activities provided by universities and institutions can increase college students' participation in physical activity and help prevent weight gain. On the other hand, the fact that the majority of lessons at universities consist of classroom lectures and require sitting to study may lead students to a sedentary lifestyle (17). People who don't engage in regular physical activity are more prone to gaining weight and facing an increased risk of obesity compared to those who maintain an active lifestyle. Reduced physical activity contributes to obesity, and obesity, in turn, results in decreased physical activity (18).

The reasons explained above indicate that college students and young adults are at risk of overweight and obesity. Numerous studies in the literature investigate the impacts of obesity on a wide variety of systems, structures and functions, but most of the studies have been conducted in the geriatric individuals (19,20). There are a limited number of studies on the multidimensional effects of obesity on physical fitness and functions in healthy college students or young adults. We think that investigating the effects of body mass index (BMI) on college students is important in terms of increasing the approaches of universities toward gaining physical activity habits. We also predict that our study will shed light on the need for physiotherapy and rehabilitation for obese individuals. This study aims to investigate the effect of BMI on balance, trunk muscle endurance, functional mobility, and physical activity in college students.

## Methods

### Study Design

This prospective and cross-sectional study was approved by Bezmialem Vakıf University Non-interventional Research Ethics Committee (decision number: 23/307, date: 18.12.2018). The study was conducted in compliance with the Declaration of Helsinki. The study was carried out in Bezmialem Vakıf University and conducted with college students studying at

the Faculty of Health Sciences. College students who agreed to participate in the study were informed about the research and an informed consent was obtained from the students.

The inclusion criteria of the study were being a college student between the ages of 18-25, not having an orthopedic and/or neurological disease that could hinder the evaluation process, and agreeing to participate in the study. Exclusion criteria were being diagnosed with a musculoskeletal system disease, having recently undergone an orthopedic operation, using insoles, and playing a sport professionally as this could affect the results.

**Outcomes**

College students' age, gender, presence of comorbidities, orthopedic surgery history and insoles use were recorded via a demographic information form constituted by the researchers. Balance was assessed using the biodex balance system (BBS) with the results of postural stability test (PST), limits of stability test (LOST), and clinical test of sensory integration of balance (CTSIB). Trunk muscle endurance was measured through the Biering-Sorensen test and McGill trunk flexor endurance test, functional mobility was evaluated with the 30-second sit-to-stand test (30STS), and physical activity levels were determined using the International Physical Activity Questionnaire-Short Form (IPAQ-SF).

**BMI**

Weight and height were measured to compute the BMI. These measurements were conducted with students standing, barefoot, and dressed in light clothing after fasting for a minimum of two hours. Tanita CO Tokyo-Japan (TANITA MC 180 MA) model digital scale was used for weight measurement and the values were recorded in kilograms (kg). Height measurement was made with a tape measure and recorded in centimeters (cm). BMI was calculated with the kilogram/meter$^2$ (kg/m$^2$). According to the calculated BMI, the college students were divided into four groups: underweight (BMI <18.5 kg/m$^2$), normal (18.5≤ BMI ≤24.99 kg/m$^2$), overweight (25.0≤ BMI ≤29.99 kg/m$^2$), and obese (BMI ≥30 kg/m$^2$) (21).

**Balance**

Balance evaluation performed with PST, LOST and CTSIB with help of the BBS (Biodex, Inc., Shirley). Ability to maintain the center of gravity within the support surface was evaluated with PST. Overall stability index, anterior-posterior stability index, and medial-lateral stability index were recorded during PST. Greater scores indicate poorer postural stability. The assessment of the ability to shift the center of gravity in five directions was conducted using LOST. LOST was applied on a static platform and the directional control of the students was evaluated as overall, forward, backward, left, right, forward-right, forward-left, backward-right and backward-left, recorded as a percentage. Higher scores in LOST results indicate better performance and dynamic postural stability. With CTSIB, it was evaluated how different senses contribute to balance and how well balance can be compensated when one or more of these senses are eliminated. CTSIB was applied in four different positions with static platform setting: eyes open firm surface, eyes closed firm surface, eyes open foam surface, and eyes closed foam surface. Oscillations for each position were calculated as a sway index, and high sway index scores refer to the increase with balance deterioration (22).

**Trunk Muscle Endurance**

Trunk extensor muscle endurance evaluated with the Biering-Sorensen test. During the test, the pelvis and lower extremities were fixed to the bed by the researcher. Students were asked to cross their hands on opposite shoulders and keep their trunks outside the bed in a position parallel to the floor for the maximum amount of time. Trunk flexor muscle endurance evaluated with the McGill trunk flexor endurance test. During the test, the individuals' feet remained in contact with the bed surface, the hips and knees were positioned in 90° flexion, and the trunk was positioned in 60° flexion. Students were asked to maintain this position for the maximum amount of time they could. For both tests, when the students could not control their posture or reached the maximum time of 240 seconds, the test was finished and the test result was recorded in seconds (23,24).

**Functional Mobility**

Functional mobility assessed with 30STS. The assessment was conducted using a standard chair with a height of 43 cm. Students were asked to cross their hands on opposite shoulders and perform maximum sit-to-stand activity by maintaining this position throughout the test period. At the end of the test, the number of repetitions for 30 seconds was recorded. The 30STS is also applicable for assessing lower extremity muscle strength in young adults (25).

**Physical Activity**

IPAQ-SF was used to measure physical activity levels of college students. IPAQ-SF includes a total of 7 questions in 4 separate sections regarding activities done for at least 10 minutes in the last 7 days. Walking, moderate, vigorous physical activity and, sitting time scores were determined and the total physical activity score was obtained by summing the all values. The activities in the questionnaire are scored as "metabolic equivalent (MET)-minutes/week (MET-min/wk) unit" (Total physical activity min/wk: time spent on vigorous + moderate + walking; MET min/wk: 8 × vigorous + 4 × moderate + 3.3 × walking) (26).

**Statistical Analysis**

G-power v3.1 program (Universitat Kiel, Germany) was used to determine the sample size. Based on the results of a study in the literature (27), we estimated that a minimum of 52 participants in total should be included in the study for 4 groups, 13 participants for each group. Sample size calculation was made based on the mean and standard deviation values of the Biering-Sorensen test within 80% power and 95% confidence interval. Data analysis was conducted using Statistical Package for Social Sciences (SPSS) Statistics v.26 (SPSS Inc., USA). Normal distribution characteristics of all groups were examined with the Shapiro-Wilk test. One-way analysis of variance (ANOVA)

test was used to compare normally distributed data and for variables with significant differences, Tukey honestly significant difference test was used as a post hoc test to determine which groups the difference was between. Kruskal-Wallis test was used to compare data that did not show normal distribution. Since there is no post hoc test that can be used in nonparametric tests, Mann-Whitney U test was used as two comparisons for four groups to determine which groups the variables with significant differences were between. Relationships between normally distributed data were examined with the Pearson correlation coefficient, and relationships between non-normally distributed data were examined with the Spearman correlation coefficient. Correlation strength level was evaluated according to Cohen's Kappa coefficient. Correlation strength was categorized as "very weak" (0.00-0.19), "weak" (0.20-0.39), "moderate" (0.40-0.59), "strong" (0.60-0.79), and "very strong" (0.80-1.00). In all analyses, $p<0.05$ (two-sided) was considered statistically significant.

## Results

College students studying in the departments of the faculty of health sciences were invited to the study (n=110). According to the study's inclusion-exclusion criteria, 37 college students were excluded from the study (Figure 1). A total of 73 college students, 53 female (72.6%) and 20 male (27.4%), participated in the study. The college students participating in the study were studying in the departments of nutrition and dietetics (n=9), occupational therapy (n=12), physiotherapy and rehabilitation (n=26), nursing (n=11), audiology (n=7), and health management (n=8). Mean age of the participants was 20.76±1.11 years, and the mean BMI was 25.02±1.53 kg/m$^2$. The demographic characteristics of the participants in the study are shown in Table 1.

No statistically significant difference was found in the PST, LOST and CTSIB results of balance measurements between groups with different BMI ($p>0.05$). Comparison of the values in balance among groups is given in Table 2. Mean scores of Biering-Sorensen and McGill trunk flexor endurance tests were 110.05±42.35 and 122.07±70.52 seconds, respectively. In Biering-Sorensen and McGill trunk flexor endurance tests, a statistically significant difference was observed between the groups ($p<0.001$; $p=0.001$). According to the Biering-Sorensen test results, obese students had significantly lower scores than underweight and normal weight students ($p<0.001$; $p<0.001$). At the same time, obese students had significantly lower McGill trunk flexor endurance test results than underweight and normal weight students ($p=0.002$; $p=0.003$). Mean scores of 30STS, which used to evaluate functional mobility, was 27.17±3.68 repetitions. There was no statistically significant difference between the groups in 30STS scores ($p=0.243$). While there was no statistically significant difference between the groups in vigorous physical activity, moderate physical activity, walking and total score in IPAQ-SF ($p>0.05$), there was a statistically significant difference between the groups in sitting time ($p=0.005$). Underweight students had less sitting time compared to normal weight and obese students ($p=0.004$; $p=0.004$). Comparison of the values in trunk muscle endurance, functional mobility, and physical activity among groups are given in Table 3.

BMI and Biering-Sorensen test and McGill trunk flexor endurance test showed a significant negative correlation ($r=-0.477$, $p=0.000$; $r=-0.487$, $p=0.000$). At the same time, BMI showed a statistically significant relationship with vigorous physical activity and sitting time ($r=0.272$, $p=0.028$; $r=0.411$, $p=0.001$). However, no significant relationship was found between BMI and balance, functional mobility, and total physical activity scores ($p>0.05$). Correlation between BMI and balance, trunk muscle endurance, functional mobility, and physical activity is given in Table 4.

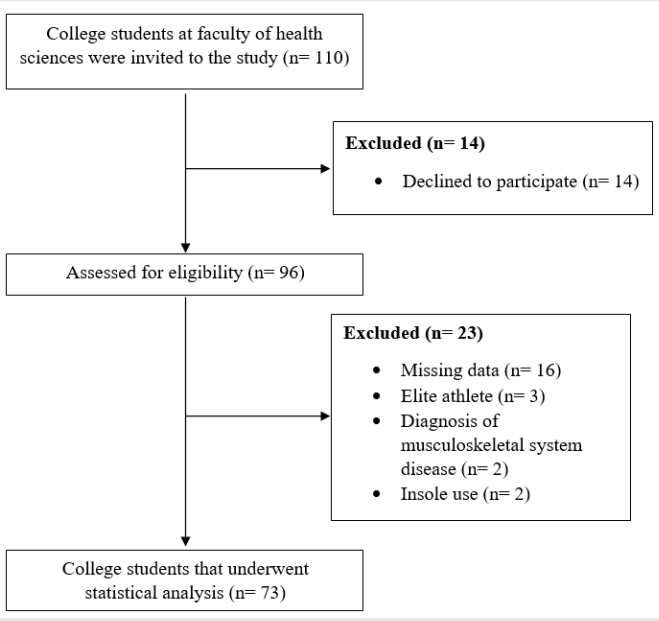


**Figure 1.** Flow chart of the study

**Table 1.** Demographic characteristics of groups

| Characteristics | Total (n=73) | Underweight (<18.5 kg/m²) (n=18) | Normal (18.5-24.99 kg/m²) (n=22) | Overweight (25.0-29.99 kg/m²) (n=16) | Obese (≥30 kg/m²) (n=17) |
|---|---|---|---|---|---|
| Age (years) | 20.76±1.11 | 20.61±1.14 | 20.50±1.05 | 21.18±1.60 | 20.77±0.66 |
| Height (cm) | 166.95±8.48 | 167.69±7.75 | 162.36±7.08 | 165.31±8.56 | 172.44±10.56 |
| Weight (kg) | 70.42±8.37 | 50.37±4.19 | 57.84±7.88 | 72.93±9.37 | 100.56±12.06 |
| BMI (kg/m²) | 25.02±1.53 | 17.88±0.49 | 21.85±1.90 | 26.56±1.20 | 33.81±2.55 |

Data are presented as mean ± standard deviation. BMI: Body mass index

**Table 2.** Comparison of the values in balance among groups

| | Underweight (<18.5 kg/m²) (n=18) | Normal (18.5-24.99 kg/m²) (n=22) | Overweight (25.0-29.99 kg/m²) (n=16) | Obese (≥30 kg/m²) (n=17) | p-value |
|---|---|---|---|---|---|
| PST/overall | 0.32±0.14 | 0.30±0.11 | 0.35±0.14 | 0.23±0.10 | 0.205 |
| PST/anterior/posterior | 0.22±0.12 | 0.21±0.10 | 0.27±0.12 | 0.16±0.07 | 0.113 |
| PST/medial/lateral | 0.12±0.05 | 0.14±0.07 | 0.16±0.09 | 0.08±0.06 | 0.101 |
| LOST/overall | 47.33±10.86 | 47.27±9.21 | 45.93±10.09 | 44.44±12.27 | 0.955 |
| LOST/forward | 64.05±10.72 | 59.68±15.28 | 64.34±15.86 | 59.44±13.80 | 0.634 |
| LOST/backward | 50.50±16.81 | 53.72±13.24 | 50.06±17.39 | 58.55±15.50 | 0.544 |
| LOST/left | 53.94±18.47 | 54.27±13.50 | 52.68±12.66 | 53.77±20.22 | 0.980 |
| LOST/right | 55.27±16.06 | 54.81±11.82 | 50.68±14.04 | 45.11±19.51 | 0.310 |
| LOST/forward right | 53.11±13.80 | 49.77±13.00 | 54.56±11.40 | 46,66±21,18 | 0.510 |
| LOST/forward left | 46.72±12.60 | 48.86±15.72 | 50.56±15.90 | 54.55±9.15 | 0.585 |
| LOST/backward right | 48.22±13.06 | 45.00±13.69 | 44.81±15.73 | 43.22±16.16 | 0.721 |
| LOST/backward left | 47.72±17.49 | 50.81±15.30 | 43.12±14.10 | 50.33±11.40 | 0.462 |
| CTSIB/eyes open firm surface | 0.47±0.23 | 0.55±0.23 | 0.54±0,21 | 0.49±0.16 | 0.475 |
| CTSIB/eyes closed firm surface | 0.72±0.20 | 0.93±0.46 | 0.87±0.27 | 0.91±0.20 | 0.178 |
| CTSIB/eyes open foam surface | 0.90±0.10 | 0.94±0.30 | 0.96±0.25 | 0.84±0.16 | 0.596 |
| CTSIB/eyes closed foam surface | 2.28±0.35 | 2.50±0.57 | 2.46±0.47 | 2.43±0.50 | 0.549 |
| CTSIB/composite score | 1.09±0.17 | 1.23±0.27 | 1.25±0.25 | 1.17±0.19 | 0.190 |

Higher scores on the PST, and CTSIB indicate greater balance impairment. Lower scores on the LOST indicates greater dynamic balance dysfunction. Data are presented as mean ± standard deviation.
PST: Postural stability test, LOST: Limits of stability test, CTSIB: Clinical test of sensory integration of balance

**Table 3.** Comparison of the values in trunk muscle endurance, functional mobility, and physical activity among groups

| | Underweight (<18.5 kg/m²) (n=18) | Normal (18.5-24.99 kg/m²) (n=22) | Overweight (25.0-29.99 kg/m²) (n=16) | Obese (≥30 kg/m²) (n=17) | p-value |
|---|---|---|---|---|---|
| Biering-Sorensen test (s) | 138.25±63.82 | 137.40±40.38 | 107.25±35.98 | 57.33±29.21 | **0.000** |
| McGill trunk flexor endurance test (s) | 181.72±82.87 | 148.55±77.85 | 99.88±70.80 | 58.11±50.58 | **0.001** |
| 30STS (reps) | 26.22±4.25 | 26.95±3.10 | 28.75±3.37 | 26.77±4.02 | 0.243 |
| Vigorous (MET-min/week) | 102.22±265.76 | 450.90±1096.22 | 630.00±1058.45 | 343.66±642.66 | 0.306 |
| Moderate (MET-min/week) | 251.25±342.02 | 346.36±480.05 | 302.50±300.29 | 53.33±89.44 | 0.216 |
| Walking (MET-min/week) | 1639.32±1356.43 | 1735.10±990.14 | 1949.35±1632.41 | 2052.16±2182.71 | 0.834 |
| Sitting (MET-min/week) | 459.33±198.11 | 645.54±195.65 | 618.75±222.04 | 757.33±222.36 | 0.005 |
| Total (MET-min/week) | 1992.79±1427.43 | 2532.37±1431.66 | 2881.85±2028.67 | 2449.16±2708.90 | 0.384 |

Data are presented as mean ± standard deviation. Bold denotes p<0.05. 30STS: 30-second sit-to stand test, s: seconds, reps: Repetitions, MET: Metabolic equivalent, min: Minute. Higher scores on the Biering-Sorensen test, McGill trunk flexor endurance test and, 30STS indicate greater performance

**Table 4.** Correlation between BMI and balance, trunk muscle endurance, functional mobility, and physical activity

| Outcomes | BMI | |
|---|---|---|
| | r-value | p-value |
| PST/overall | -0.012 | 0.926 |
| LOST/overall | -0.014 | 0.909 |
| CTSIB/composite score | 0.147 | 0.243 |
| Biering-Sorensen test | -0.477 | **0.000** |
| McGill trunk flexor endurance test | -0.487 | **0.000** |
| 30STS | 0.153 | 0.223 |
| IPAQ-SF/total (MET-min/week) | 0.137 | 0.278 |

P-values were calculated from pearson correlation test. Bold denotes p<0.05. BMI: Body mass index, PST: Postural stability test, LOST: Limits of stability test, CTSIB: Clinical test of sensory integration of balance, 30STS: 30-second sit-to stand test, IPAQ-SF: International Physical Activity Questionnaire-Short Form, MET: Metabolic equivalent, min: Minute

## Discussion

In our study which conducted with college students, the effect of BMI on balance, trunk muscle endurance, functional mobility and physical activity was investigated. Our study showed that among college students with different BMIs, both trunk extensor and trunk flexor muscle endurance values of underweight and normal weight students were better than obese students. In terms of physical activity, normal weight and obese students spent more sedentary time compared to underweight students. At the same time, this study revealed that there were no differences in balance and functional mobility between students with different BMI.

There are studies investigating the effects of obesity on balance in healthy individuals, but most of the studies were conducted with children, adults and elderly groups. The number of studies investigating the effects of obesity on balance in healthy college students or young adults is limited in the literature. In a study conducted on sedentary female college students, it was found that anthropometric characteristics such as BMI and waist-hip ratio did not affect dynamic and static balance (28). Likewise, Suvarna et al. (29) showed in their study on college students that increasing BMI did not cause any impact on dynamic balance. In this respect, our study results are parallel to the literature. We think that the lack of relationship in our results may be due to the similarity of the lower extremity muscle strengths of the college students in our study, evaluated with 30STS. In their research, Hue et al. (30) identified a notable correlation between increased body weight and decreased postural stability among adult males. The relationship between BMI and balance in geriatric individuals was investigated and it was revealed that increasing body weight negatively affected balance and postural stability (31). Du Pasquier et al. (32) examined the correlation between age and postural stability and found that increasing age had negative effects on postural stability, regardless of height, weight and gender. Considering the results of the studies in the literature and our study, it is seen that increasing body weight in young adults does not significantly affect balance. However, when there are negative effects of aging in addition to increasing body weight, balance may be more affected in obese individuals.

In a study investigating the correlation between BMI and transversus abdominis (TrA) muscle endurance in college students, it was reported that students with higher BMI had lower TrA muscle endurance (33). In the study of Malayil et al. (34), a negative relationship was found between abdominal muscle endurance and BMI in sedentary college students. A study conducted on Korean college students revealed that obesity negatively affected both muscle endurance and cardiorespiratory endurance (35). In their study with healthy young adults, Pasupatham et al. (36) investigated the effect of BMI on the endurance of the lower back extensor muscles in underweight, normal weight and overweight individuals. The authors reported in their study that there was a negative correlation between BMI and lower back extensor muscle endurance. The data obtained from our study were compatible with the literature. We think that the positive, moderately significant correlation between the BMI and sedentary time of the college students in our study may affect the students' trunk muscle endurance, and in addition to the increase in BMI, spending more time sitting may reduce trunk muscle endurance. Mayer et al. (37) investigated the effects of obesity on back and core muscle endurance in adult firefighters using the modified Biering-Sorensen test and plank test. In that study, the authors found that non-obese adults had significantly better results on both trunk extensor and trunk flexor muscle endurance tests compared to the obese group. Pardeshi et al. (38) examined the relationship between BMI and core muscle endurance in adult sedentary women and reported that obese women had weaker core muscle endurance compared to normal weight women. In a study conducted on children aged 10-13, it was stated that BMI showed a negative correlation with abdominal muscle endurance (39). Studies in the literature show that increased BMI begins to negatively affect trunk muscle endurance starting from childhood. Studies conducted on adult and geriatric individuals reveal that increasing BMI continues to negatively affect trunk muscle endurance in later ages. Trunk muscle endurance has a critical role in maintaining balance and functional performance (40). Decrease in trunk muscle endurance can lead to falls, postural disorders and decreased functionality, especially in later ages (41). For this reason, we believe that preventing obesity at young ages is important for the preservation of trunk muscle endurance and public health.

To the best of our knowledge our study is the first to investigate the relationship between BMI and functional mobility in college students. A significant portion of the studies in the literature on this subject have been conducted with adult and geriatric individuals. Brady et al. (42) evaluated functional mobility in elderly women with 30STS and stated that the results were better in normal weight women than overweight women. Pataky et al. (43) investigated the effect of obesity on functional mobility in women and reported that obese women had significantly lower functional mobility levels compared to normal weight women. In a study among adult women by Hergenroeder et al. (44), being of normal weight was associated with better sit-to-stand test results. Ryder et al. (45) investigated the effect of bariatric surgery on functional mobility in obese young people. According to the results of that study, it was revealed that functional mobility results in young people after bariatric surgery were better at the sixth month and second year than before surgery. Contrary to the literature, in our study, there was no significant difference in functional mobility test scores between college students with different BMIs. We think that this may be due to the similar physical activity levels of the students participating in the study.

Contrary to our study, many studies that used IPAQ in the evaluation and investigated the relationship between BMI and physical activity have shown that increasing body weight negatively affects the level of physical activity. Cleland et al. (46) affirmed that prolonged sitting duration and insufficient physical activity levels were linked to obesity among young adults. It has also been observed that the possibility of obesity increases in men who have lower step counts. In a study which conducted with university students, a significant negative correlation was found between BMI and duration of vigorous physical activity that assessed by

IPAQ-SF (47). Sulemana et al. (48) investigated the relationship between physical activity levels and BMI values in their study on adolescent girls aged between 14-17. The authors reported that the overweight adolescents had lower physical activity levels compared to the normal weight adolescents. They also stated that there was a significant negative correlation between BMI values and total physical activity score of all participants in the study. However, there are also studies in the literature that support our results. Arslan et al. (49) reported in their study with university students that no significant relationship was found between BMI and physical activity level assessed by IPAQ-SF. Göger et al. (50) found that obesity in adult women significantly reduced healthy lifestyle behaviors but did not affect physical activity level. We think that since the college students participating in our study are educated in health sciences, their knowledge about the possible complications of obesity may motivate overweight and obese students to do physical activity and exercise. We also think that the fact that IPAQ-SF is a subjective physical activity assessment questionnaire based on self-report may also affect the results.

### Study Limitation

In our study, the relationship between BMI and physical fitness of college students was evaluated multidimensionally. Balance was evaluated with an objective method, and the effects of BMI on many systems and structures were revealed. At the same time, our study achieved the aim of providing universities and institutes with a perspective on obesity prevention. These are among the strengths of our study. However, our study has some limitations. The study was single-centered, physical activity was not assessed with an objective measurement method, and the sample size was small. We think that there is a need for studies in the literature on BMI, where physical activity levels are evaluated with objective measurement methods, with a larger sample size, multi-centered and with different age groups.

## Conclusion

According to the results of this study, although increasing BMI negatively affects trunk muscle endurance and increases sitting time in college students, there is no effect on balance, functional mobility and physical activity. For this reason, exercises to improve trunk muscle endurance should be added to the physiotherapy and rehabilitation programs of students with high BMI. However, studies conducted with geriatric individuals show that increasing body weight negatively affects balance, functional mobility and physical activity. Considering the changes that occur with aging in addition to increasing body weight, we can say that obese individuals will experience the negative effects of the parameters examined in the study more severely in later ages. We suggest that universities should enhance activities and events aimed at increasing college students' physical activity habits in order to prevent a sedentary lifestyle that may increase with age.

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### Ethics

**Ethics Committee Approval:** This prospective and cross-sectional study was approved by Bezmialem Vakıf University Non-interventional Research Ethics Committee (decision number: 23/307, date: 18.12.2018).

**Informed Consent:** College students who agreed to participate in the study were informed about the research and an informed consent was obtained from the students.

### Footnotes

### Authorship Contributions

Surgical and Medical Practices: K.A., Concept: K.A., A.K., Design: K.A., A.K., Data Collection or Processing: K.A., G.C.T., Analysis or Interpretation: K.A., A.K., G.C.T., Literature Search: K.A., A.K., G.C.T., Writing: K.A., A.K., G.C.T.

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