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Original Article

Correlation of BMI and Postural Balance Using Functional Stability Tests

Nimra Aslam[1], Sana Arif[1], Muhmmad Mahmood Alam[1], M Waseem Akhtar[1]

[1] Department of Physical Therapy, Akhtar Saeed College of Rehabilitation Sciences, Lahore, Pakistan

*Corresponding author: Nimra Aslam, numraaslam20@gmail.com

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ABSTRACT

Background: Body mass index (BMI) is a widely used indicator of weight status and may influence postural control through altered body alignment, joint loading, proprioception, and neuromuscular coordination. Functional stability is essential for safe mobility, yet evidence regarding the relationship between BMI and balance performance in young adults remains limited. **Objective:** This study aimed to determine the correlation between BMI and postural balance among young adults using functional stability tests. **Methods:** A cross-sectional observational study was conducted at Akhtar Saeed Medical and Dental College, Lahore, over six months. A total of 140 participants aged 20–25 years, including 70 males and 70 females, were recruited through non-probability convenience sampling. Height and weight were measured to calculate BMI. Static balance was assessed using the Single-Leg Stance test, while dynamic balance and functional mobility were assessed using the Timed Up and Go test. **Results:** Participants with higher BMI demonstrated reduced functional stability. Mean Single-Leg Stance time decreased from 28.5 seconds in the normal-BMI group to 18.2 seconds in the higher-BMI group, while Timed Up and Go completion time increased from 8.4 seconds to 12.7 seconds. Both associations were statistically significant ($p < 0.001$). **Conclusion:** Higher BMI was significantly associated with poorer static and dynamic balance among young adults, supporting the need for early screening and targeted interventions to improve postural control. **Keywords:** Body mass index, postural balance, functional stability, Single-Leg Stance, Timed Up and Go, young adults.

INTRODUCTION

Balance control is a fundamental requirement for safe functional movement, upright posture, and independent mobility. It allows individuals to maintain the body's center of mass within the base of support during quiet standing and to preserve stability during movement-based activities such as walking, turning, running, and transitional tasks (1). Static balance refers to the ability to maintain postural stability during stationary positions, whereas dynamic balance reflects the ability to control posture during voluntary movement or external perturbation. Effective postural control depends on the coordinated integration of visual, vestibular, and somatosensory inputs by the central nervous system, followed by timely neuromuscular responses that stabilize the body during daily activities (2,3).

Postural balance is influenced by multiple biological and functional factors, including age, sex, body mass index, body composition, muscular strength, proprioceptive acuity, and physical activity level (4). Alterations in body weight status may affect balance by changing joint loading, segmental alignment, plantar pressure distribution, muscle recruitment patterns, and the efficiency of ankle, hip, and stepping strategies used to maintain equilibrium. Although both low and high body mass may influence postural control, excess body weight has received increasing attention because of its association with impaired locomotion, altered gait mechanics, greater musculoskeletal stress, and increased instability during weight-bearing activities (5,6).

Body mass index is widely used as a practical anthropometric indicator of weight status and provides a simple method for classifying individuals according to relative body mass. Although BMI does not directly distinguish fat mass from lean mass, it remains clinically useful in population-based screening and in studies examining the relationship between weight status and functional performance (7,8). Increased BMI may compromise postural control through several interconnected mechanisms, including anterior displacement of the center of gravity, reduced ability to generate rapid corrective torque, increased load on the ankle-foot complex, impaired proprioceptive feedback, and reduced movement efficiency. These changes may challenge both static balance, such as maintaining a single-leg stance, and dynamic balance, such as rising from a chair, walking, turning, and sitting again during functional mobility testing (9,10).

Assessment of balance is clinically important because early postural deficits may precede functional limitation, reduce movement confidence, and increase susceptibility to instability-related events. Several clinical tools are available to assess balance and mobility, including the Berg Balance Scale, Functional Reach Test, Star Excursion Balance Test, Y-Balance Test, Single-Leg Stance test, and Timed Up and Go test. Among these, the Single-Leg Stance test provides a simple measure of static postural control, while the Timed Up and Go test evaluates dynamic balance and functional mobility through a sequence of sit-to-stand transfer, walking, turning, and return-to-sit movement (11,12). These tests are practical, low-cost, and suitable for clinical and community-based assessment where advanced force-platform analysis may not be available.

Previous studies have reported associations between obesity, postural sway, altered plantar loading, impaired dynamic balance, and reduced functional mobility across different age groups. Evidence from young adults, older adults, children, and clinical populations suggests that excess body weight may negatively influence balance performance, although findings are not always consistent across static and dynamic balance outcomes. Some studies have demonstrated poorer dynamic balance among individuals with higher BMI, whereas others have reported weaker or nonsignificant associations for static one-leg stance performance. These differences may be explained by variation in participant age, sex distribution, physical activity level, body composition, balance assessment tools, and the operational definition of obesity or overweight (13,14).

Despite growing evidence linking BMI with postural control, an important knowledge gap remains regarding the relationship between BMI and functional stability in young adults. Young adulthood is generally considered a period of peak physical capacity, yet lifestyle-related increases in body mass during this stage may already influence neuromuscular control, lower-limb loading, and movement quality. Studying this relationship in young adults may therefore help identify early functional changes before more obvious mobility limitations or fall-related consequences develop. This is particularly relevant in settings where simple clinical screening tools can guide early preventive strategies, including weight management, strengthening, proprioceptive training, and balance-focused rehabilitation (15).

Therefore, this study aimed to determine the correlation between BMI and postural balance among young adults by assessing static balance through the Single-Leg Stance test and dynamic balance through the Timed Up and Go test. The research question was: among young adults aged 20–25 years, is higher BMI associated with poorer static and dynamic balance performance as measured by functional stability tests?

MATERIALS AND METHODS

This cross-sectional observational study was conducted at Akhtar Saeed Medical and Dental College, Lahore, over a period of six months to determine the relationship between body mass index and postural balance among young adults. The study design was selected because it allowed simultaneous measurement of anthropometric status and functional balance performance in a defined population at a single point in time. The target population consisted of young adult male and female participants aged 20–25 years who were available during the study period and met the predefined eligibility criteria. A total of 140 participants were enrolled, including 70 males and 70 females, using a non-probability convenience sampling technique.

Participants were eligible for inclusion if they were aged 20–25 years, able to walk independently without an assistive device, and had no history of previous injury or surgery affecting mobility or balance. Individuals were excluded if they had neurological, cardiovascular, metabolic, rheumatic, or vestibular disorders; were taking medications known to affect balance, including antidepressants, antihypertensives, or anticonvulsants; or had clinical evidence of ankle or knee instability based on positive anterior or posterior drawer testing. These criteria were applied to reduce the influence of pre-existing disease, medication-related balance disturbance, and lower-limb joint instability on functional stability outcomes.

Eligible participants were approached through the study setting and were briefed regarding the purpose, procedures, and expected duration of participation. Written informed consent was obtained before data collection. Each participant completed a demographic information form, after which anthropometric and balance-related measurements were collected under supervision. Data collection was performed in a controlled environment using the same assessment sequence for all participants to maintain procedural consistency and reduce measurement variability.

Body weight was measured in kilograms using a digital weighing scale, and standing height was measured in meters using a stadiometer. Body mass index was calculated using the standard formula: weight in kilograms divided by height in meters squared. BMI was treated as the primary exposure variable and was also categorized for descriptive analysis. Postural balance was assessed using two functional stability tests. Static balance was measured using the Single-Leg Stance test, and dynamic balance was measured using the Timed Up and Go test. For the Single-Leg Stance test, participants were instructed to stand on one leg on a flat and stable surface, and the duration for which balance was maintained was recorded in seconds using a stopwatch. For the Timed Up and Go test, participants began in a seated position on a chair and, on the command “Go,” stood up, walked a distance of three meters, turned around, walked back to the chair, and sat down again. The total time required to complete the task was recorded in seconds using a stopwatch.

The main study variables included BMI, Single-Leg Stance duration, and Timed Up and Go completion time. BMI represented body weight status, Single-Leg Stance duration represented static postural balance, and Timed Up and Go completion time represented dynamic balance and functional mobility. Age and sex were recorded as demographic variables. Higher Single-Leg Stance duration indicated better static balance, whereas longer Timed Up and Go completion time indicated poorer dynamic balance performance. The outcome measures were recorded numerically to allow correlation-based analysis between BMI and functional stability performance.

To reduce information bias, all assessments were performed under direct supervision using standardized instructions. The same measurement approach was applied across participants, and all balance tests were conducted on a flat and stable surface to minimize environmental variation. Participants were screened using predefined eligibility criteria to reduce confounding from medical conditions, medications, and lower-limb instability that could independently affect postural control. Equal enrollment of males and females was maintained to improve sex balance within the study sample.

The sample size was calculated using the Taro Yamane formula, assuming a source population of 1500 participants and a 95% confidence level, resulting in a final sample of 140 participants. Data were entered, coded, and checked for completeness before analysis. Continuous variables, including age, BMI, Single-Leg Stance time, and Timed Up and Go time, were summarized using appropriate descriptive statistics. Categorical variables, including sex and BMI category, were summarized as frequencies and percentages. The association between BMI and postural balance outcomes was assessed using correlation analysis. The relationship between BMI and Single-Leg Stance performance was analyzed to determine the association between body mass status and static balance, while the relationship between BMI and Timed Up and Go performance was analyzed to determine the association between body mass status and dynamic functional mobility. Statistical significance was evaluated using a two-tailed p-value threshold of less than 0.05.

Ethical approval was obtained from the relevant institutional review board or ethics committee before data collection. All procedures were conducted according to established ethical standards. Participation was voluntary, informed consent was obtained from all participants, and participant information was handled confidentially. Data integrity was maintained through supervised data collection, standardized measurement procedures, consistent variable coding, and review of completed forms before statistical analysis.

RESULTS

A total of 140 young adults aged 20–25 years were included in the analysis. The study sample was evenly distributed by sex, with 70 males and 70 females. Age distribution showed that participants aged 22 years formed the largest subgroup, accounting for 38 participants, followed by 24-year-old participants, who accounted for 37 participants. BMI classification showed that 87 participants were in the normal BMI category, while 53 participants were classified in the higher BMI category. Functional stability was assessed using the Single-Leg Stance test for static balance and the Timed Up and Go test for dynamic balance, as described in the study methods.

Table 1. Demographic and BMI Distribution of Participants

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	70	50.0
Sex	Female	70	50.0
Age	20 years	1	0.7
Age	21 years	17	12.1
Age	22 years	38	27.1
Age	23 years	31	22.1
Age	24 years	37	26.4
Age	25 years	16	11.4
BMI category	18–24 kg/m²	87	62.1
BMI category	>24 kg/m²	53	37.9
Total	—	140	100.0

The age profile showed a narrow young-adult distribution, with all participants between 20 and 25 years. The highest proportion was observed at 22 years, representing 27.1% of the sample, followed closely by 24 years at 26.4%. Participants aged 20 years represented the smallest subgroup, contributing only 0.7% of the total sample. BMI distribution showed that 62.1% of participants had BMI values between 18 and 24 kg/m², whereas 37.9% had BMI values greater than 24 kg/m². The equal male-to-female ratio provided balanced sex representation across the total sample.

Table 2. Functional Stability Performance According to BMI Category

Functional Stability Outcome	BMI Category	Mean	95% Confidence Interval	p-value
Single-Leg Stance time, seconds	18–24 kg/m²	28.5	26.3–30.7	<0.001
Single-Leg Stance time, seconds	>24 kg/m²	18.2	16.1–20.3	<0.001
Timed Up and Go time, seconds	18–24 kg/m²	8.4	7.9–8.9	<0.001
Timed Up and Go time, seconds	>24 kg/m²	12.7	11.8–13.6	<0.001

Functional balance performance differed across BMI categories. Participants with BMI values between 18 and 24 kg/m² maintained single-leg stance for a mean duration of 28.5 seconds, with a 95% confidence interval of 26.3–30.7 seconds. In comparison, participants with BMI values greater than 24 kg/m² maintained single-leg stance for a mean duration of 18.2 seconds, with a 95% confidence interval of 16.1–20.3 seconds. This represents a 10.3-second lower mean SLS duration in the higher BMI group, indicating reduced static balance performance. Dynamic mobility followed the same clinical pattern. Participants in the 18–24 kg/m^2 BMI category completed the Timed Up and Go test in a mean time of 8.4 seconds, while those in the >24 kg/m^2 category required 12.7 seconds. The 4.3-second increase in TUG completion time among participants with higher BMI indicates slower functional mobility and poorer dynamic balance performance. Both SLS and TUG differences were statistically significant at $p < 0.001$.

Table 3. Correlation Between BMI and Functional Stability Outcomes

Association Tested	Pearson Correlation Coefficient (r)	Sample Size (n)	p-value
BMI and Single-Leg Stance	0.896	140	<0.001
BMI and Timed Up and Go	0.804	140	<0.001

Correlation analysis showed statistically significant associations between BMI and both functional stability outcomes. The association between BMI and Single-Leg Stance was strong, with a Pearson correlation coefficient of $r = 0.896$ and $p < 0.001$. The association between BMI and Timed Up and Go was also strong, with $r = 0.804$ and $p < 0.001$. Both tests included all 140 participants, and both associations were significant at the 0.01 level. The magnitude of these coefficients indicates that BMI was strongly related to static and dynamic balance performance in the study population.

Overall, participants with higher BMI demonstrated poorer functional stability performance across both balance domains. Static balance, measured by Single-Leg Stance time, was lower in the higher BMI group, while dynamic balance and functional mobility, measured by Timed Up and Go time, were slower in the same group. The findings indicate that increased BMI was significantly associated with reduced postural balance among young adults, with statistically significant differences in both SLS and TUG performance and strong correlation coefficients for both balance measures.

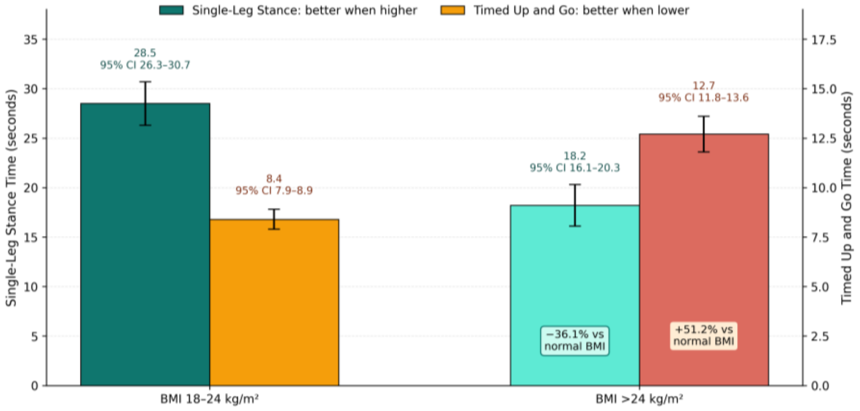

Figure 1. BMI-Related Differences in Static Balance and Dynamic Mobility Among Young Adults

The figure highlights a clinically meaningful gradient in functional stability across BMI categories. Participants with BMI 18–24 kg/m^2 demonstrated better static balance, maintaining the Single-Leg Stance for a mean of 28.5 seconds (95% CI 26.3–30.7), whereas participants with BMI >24 kg/m^2 sustained the stance for only 18.2 seconds (95% CI 16.1–20.3), representing a 36.1% reduction. Dynamic mobility showed the opposite but equally important pattern: the Timed Up and Go test increased from 8.4 seconds (95% CI 7.9–8.9) in the normal-BMI group to 12.7 seconds (95% CI 11.8–13.6) in the higher-BMI group, a 51.2% increase in completion time. Taken together, the visual pattern indicates that higher BMI was associated with both poorer static balance and slower dynamic mobility, supporting the overall finding that functional stability declines as BMI increases in young adults.

DISCUSSION

The findings of this study indicate that higher BMI is associated with reduced functional stability among young adults, as reflected by poorer performance on both static and dynamic balance measures. Participants with BMI values greater than 24 kg/m^2 demonstrated a lower mean Single-Leg Stance duration than those with BMI values of 18–24 kg/m^2, decreasing from 28.5 seconds to 18.2 seconds, while

Timed Up and Go completion time increased from 8.4 seconds to 12.7 seconds. This pattern suggests that increased body mass is related not only to reduced ability to maintain a stable single-limb posture but also to slower functional mobility during transitional and walking-based tasks. These findings support the clinical relevance of evaluating BMI as a factor associated with postural control, particularly because both SLS and TUG represent simple, low-cost, and clinically applicable measures of functional stability.

The observed reduction in Single-Leg Stance performance among participants with higher BMI may be explained by the mechanical and neuromuscular demands imposed by excess body mass. Static single-limb support requires precise control of the body's center of mass over a relatively narrow base of support, along with adequate ankle, hip, and trunk stabilization. Higher BMI may increase segmental load, alter body alignment, and shift the center of gravity anteriorly, thereby increasing the corrective torque required to maintain upright posture. In addition, increased adiposity may reduce movement efficiency and challenge proprioceptive input from the ankle-foot complex, which plays an important role in detecting postural sway and generating rapid corrective responses. These mechanisms are consistent with the rationale that BMI variations can influence muscle function, joint loading, proprioception, and neuromuscular coordination, particularly through the ankle-foot complex during standing and gait-related activities (15,16).

Dynamic balance was also poorer among participants with higher BMI, as shown by the longer TUG completion time. The TUG test requires coordinated sit-to-stand transfer, acceleration, walking, turning, deceleration, and controlled sitting, making it sensitive to deficits in lower-limb strength, postural transitions, gait adaptability, and turning control. The increase from 8.4 seconds in the normal-BMI group to 12.7 seconds in the higher-BMI group indicates a clinically meaningful slowing of functional mobility. This finding is consistent with prior work by do Nascimento et al., who reported that obesity impaired dynamic balance in young adults, particularly during functional tasks such as the TUG test (17,18). The agreement between these findings suggests that dynamic balance may be especially vulnerable to increased body mass because movement-based tasks require rapid postural adjustments and continuous control of body momentum.

The present findings also align with evidence from older adult populations showing that higher BMI and body fat mass are associated with impaired balance and greater fall-related concern. Thiamwong et al. reported that body composition, including BMI and fat mass, was related to balance performance and fear of falling among community-dwelling older adults (19). Although the current sample consisted of young adults aged 20–25 years, the similarity in direction suggests that the adverse relationship between increased body mass and postural control may begin earlier in adulthood, before age-related sensory decline and sarcopenic changes become prominent. This emphasizes the importance of identifying balance-related effects of elevated BMI during young adulthood, when preventive strategies may be more effective.

The findings further correspond with research by Caparrós-Manosalva et al., who reported differences in postural balance indicators between normal-weight and overweight or obese groups in older adults (20). While their work used posturographic parameters such as center-of-pressure behavior and Romberg-related measures, the present study used clinically practical functional tests. Despite methodological differences, both lines of evidence indicate that increased body mass is associated with altered balance performance. This convergence supports the use of simple functional tests such as SLS and TUG in settings where advanced balance platforms are unavailable, particularly for early screening and functional risk identification.

The relationship between BMI and balance may also be influenced by changes in foot loading and lower-limb stability. Yoon, Park, and Lee reported that BMI was related to plantar pressure distribution and balance performance, with higher BMI groups showing altered balance control and greater dependence on specific foot regions during postural tasks (21). These findings provide a plausible biomechanical explanation for the reduced functional stability observed in the present study. Increased body mass may alter plantar loading patterns, reduce the efficiency of foot and ankle stabilizing strategies, and increase reliance on compensatory postural mechanisms. When these compensations are insufficient, performance may decline during both single-leg stance and dynamic mobility tasks.

Some previous findings, however, have not shown significant differences in one-legged stance performance across BMI groups. Pereira et al. reported that BMI and fat mass did not produce significant differences in one-legged stance force-platform measurements among older adults, although sex-related differences in balance control were observed (22). Differences between those findings and the present results may be related to variation in population age, measurement method, physical activity level, muscle composition, and balance assessment protocol. Young adults may demonstrate distinct BMI-related functional responses because they are generally expected to have higher neuromuscular capacity, making deviations in balance performance more clearly attributable to body mass-related loading and movement-control demands.

From a clinical perspective, the combined pattern of reduced SLS duration and prolonged TUG time suggests that higher BMI may affect both the static and dynamic components of functional stability. Static balance deficits may indicate reduced postural steadiness during narrow-base or single-limb activities, whereas slower TUG performance may reflect difficulty with transitional movement, gait control, and turning. These impairments may not immediately translate into falls in young adults, but they may represent early functional changes that could progress over time if increased BMI persists. Early screening of BMI-related balance limitations may therefore help guide preventive interventions, including weight management, lower-limb strengthening, ankle-foot conditioning, proprioceptive training, and functional mobility exercises. Evidence supporting ankle and foot exercise interventions further reinforces the potential role of targeted lower-limb training in improving strength, balance, and fall-related outcomes (23).

Overall, this study contributes to the growing evidence that BMI is meaningfully associated with functional balance performance, even in a young adult population. The findings suggest that young adults with higher BMI may already demonstrate measurable reductions in static postural control and dynamic mobility, highlighting the need to address body composition and neuromuscular function before more advanced mobility impairments develop. Because BMI is an accessible screening measure and SLS and TUG are simple clinical tests, their combined use may provide a practical approach for identifying individuals who could benefit from early lifestyle, strengthening, and balance-focused interventions.

CONCLUSION

This study concluded that higher body mass index was significantly associated with reduced functional stability among young adults aged 20–25 years. Participants with BMI greater than 24 kg/m² demonstrated poorer static balance, shown by shorter Single-Leg Stance duration, and poorer dynamic balance, shown by longer Timed Up and Go completion time, compared with participants in the normal BMI category. These findings suggest that increased BMI may influence postural control, functional mobility, and balance efficiency even during young adulthood, a stage typically associated with optimal physical performance. The use of simple clinical tests such as the Single-Leg Stance and Timed Up and Go may help identify early balance-related limitations in individuals with elevated BMI and support timely preventive strategies, including weight management, lower-limb strengthening, proprioceptive training, and functional mobility exercises to improve postural stability and reduce future musculoskeletal risk

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