

Original Article

Comparison of Balance in Habitual High Heels Wearers and Flat Shoe Wearers by Star Excursion Balance Test

Wajeaha Tariq^{1*}, Muhammad Mahmood Alam², Muhammad Waseem Akhtar³, Saadia Perwaiz⁴, Muhammad Burhan⁵, Hassnain Ali⁶

¹Akhtar Saeed College of Rehabilitation Sciences Lahore, Pakistan.

²Principal, Physical Therapy, Akhtar Saeed College of Rehabilitation Sciences Lahore, Pakistan.

³Head of Department, Physical Therapy, Akhtar Saeed College of Rehabilitation Sciences Lahore, Pakistan.

⁴Assistant Professor, Physical Therapy, Akhtar Saeed College of Rehabilitation Sciences Lahore, Pakistan.

⁵Demonstrator, Physical Therapy, Akhtar Saeed College of Rehabilitation Sciences Lahore, Pakistan.

⁶Senior Lecturer Shalamar Nursing College

*Corresponding Author: Wajeaha Tariq; Email: wajeहतariq582@gmail.com

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ABSTRACT

Background: The capacity to maintain a stable and upright posture, or balance, is influenced by footwear type. High heel shoes (HHS) alter foot alignment and weight distribution, potentially impacting balance and increasing fall risk. Despite the popularity of high heels, the balance effects compared to flat shoes remain underexplored.

Objective: To compare the balance between habitual high heel wearers and flat shoe wearers using the Star Excursion Balance Test (SEBT).

Methods: A cross-sectional study was conducted from July 2022 to January 2023, including 70 female participants aged 18-35 years. Participants were habitual wearers of high heels or flat shoes for at least six months. Individuals seeking medical care for lower extremity issues or with a history of lower extremity fractures or surgeries were excluded. Balance was assessed using the SEBT, which involves reaching in eight directions from a central stance. Each participant performed three trials per direction. Leg length was measured to normalize reach distances. Data were analyzed using SPSS version 25.0. The Mann-Whitney U Test was used to compare balance between groups, with a significance threshold of $p < 0.05$.

Results: The mean age of participants was 23.83 years (SD = 3.43). For the anterior reach on the dominant side, flat shoe wearers had a significantly better balance with a mean rank of 38.93 compared to 27.50 for high heel wearers ($p = 0.031$). No significant differences were observed in other directions: anterior reach non-dominant side ($p = 0.499$), anteromedial reach dominant side ($p = 0.384$), anteromedial reach non-dominant side ($p = 0.887$), medial reach dominant side ($p = 0.174$), medial reach non-dominant side ($p = 0.524$), posteromedial reach dominant side ($p = 0.544$), posteromedial reach non-dominant side ($p = 0.913$), posterior reach dominant side ($p = 0.704$), posterior reach non-dominant side ($p = 0.350$), posterolateral reach dominant side ($p = 0.177$), and posterolateral reach non-dominant side ($p = 0.934$).

Conclusion: Habitual high heel wearers and flat shoe wearers showed no significant differences in balance across most SEBT directions, except for a significantly poorer anterior reach in high heel wearers. These findings suggest that high heel use may specifically impact anterior balance, highlighting the need for further investigation into the biomechanical and physiological impacts of high heels on balance.

Keywords: High heel shoes, flat shoes, balance, Star Excursion Balance Test.

INTRODUCTION

The capacity to maintain a stable and upright posture, commonly referred to as "balance," is a dynamic aspect of the body's posture resulting from internal forces. Balance is essentially the ability to keep the center of gravity over a base of support (1). Postural stability, in contrast, refers to the ability to maintain the center of mass (COM) without altering the base of support (BOS) (2). The center of gravity is the point where gravitational force acts, and supporting structures ensure equilibrium (3). Although wearing high heels is often detrimental to health, the practice remains socially relevant and is of public health interest due to the balance between perceived psychosexual benefits and negative neuro-musculoskeletal (N-MSK) effects. This dichotomy underscores the significance

of studying high heels as a public health concern related to social determinants of health outcomes. Numerous studies have explored the relationship between high heel shoes (HHS) and musculoskeletal (MSK) health (4).

The type of footwear significantly affects the natural alignment of the foot, with inappropriate footwear disrupting this alignment (5). For instance, flat footwear aligns the forefoot and heel, distributing weight evenly. In contrast, heeled footwear elevates the heel above the forefoot, increasing the angulation of the foot and altering weight distribution (6). Such angulations influence the alignment of the entire body, with higher heels shifting more weight to the forefoot, thereby affecting body alignment (7). Sensory inputs, including touch and proprioception, help us understand our body's position relative to its surroundings (8). When wearing footwear, the foot's direct contact with the base of support is minimized, reducing sensory feedback and potentially impairing balance in various professions (9). Footwear with softer soles diminishes proprioception further, often leading to foot discomfort and balance issues, as reported by 4 to 5 out of 10 affected individuals attributing these problems to improper footwear use (10). High heels have been worn by women for generations on special occasions, with current estimates indicating that 37% to 69% of women wear them regularly (11). Features of HHS, such as heel height, hard heel caps, and plantar-flexed areas, restrict normal foot mobility (12). A plantar-flexed foot position alters plantar pressure distribution, muscle activity around the ankle joints, and ankle range of motion (ROM), with kinematic chain reactions potentially disrupting COM displacement (13). Consequently, habitual high heel wearers may experience reduced stability, compromised postural control, and an increased risk of falls due to these biomechanical alterations (14). Data from 2002 to 2012 show a rise in high heel-related injuries, predominantly sprains and strains of the ankle or foot, highlighting a decrease in postural stability associated with HHS (15).

Postural control involves managing the COM relative to the BOS during self- and externally-initiated perturbations. It requires a complex motor skill coordinated by the proprioceptive, visual, and vestibular systems (16). Wearing HHS, characterized by reduced BOS and increased heel height, negatively impacts human mobility patterns (17). Various movement strategies, such as ankle and hip mechanisms, are employed to maintain balance during static and dynamic activities, yet HHS can impair these balance-maintaining abilities (18).

The Star Excursion Balance Test (SEBT) is a dynamic assessment tool that evaluates strength, flexibility, and proprioception. It is widely used for functional screening to assess dynamic stability, monitor rehabilitation progress, evaluate impairments post-injury, and identify individuals at high risk for lower extremity injuries. The SEBT requires extensive coordination, balance, flexibility, and strength, involving single-leg stance with maximum reach of the opposite limb across eight directions (19). Participants undergo a warm-up before standing on their dominant limb at the center of a grid, performing three trials in randomized order with designated rest periods. The test is repeated if balance is lost or foot contact is not maintained, with reach distance normalized to leg length (20).

Given the growing popularity of high heels among young women compared to the previously favored flat shoes, both footwear types have distinct consequences on balance. This study aims to compare the impact of high heels and flat shoes on body balance. The alternate hypothesis posits no significant difference in balance between habitual high heel wearers and flat shoe wearers, while the null hypothesis suggests a significant difference in balance between these two footwear types. The objective of this study is to determine and compare the balance effects of wearing high heels versus flat shoes (21).

MATERIAL AND METHODS

A cross-sectional study was conducted to compare the balance in habitual high heel wearers and flat shoe wearers. The study was carried out between July 2022 and January 2023. Participants were selected based on their habitual use of high heels or flat shoes for a minimum duration of six months. The study population comprised females aged between 18 and 35 years. Approval was obtained from the ethics review committee of Akhtar Saeed College of Rehabilitation Sciences, Lahore, and the study adhered to the principles outlined in the Declaration of Helsinki.

The sample size calculation was performed using the formula: Total Sample Size = $N = [(Z\alpha + Z\beta)/C]^2 + 3$, resulting in a required sample size of 70 participants. Individuals were excluded if they were seeking medical care for lower extremity conditions, had a history of lower extremity fractures, or had undergone previous surgical interventions in the lower extremity.

Participants underwent the Star Excursion Balance Test (SEBT) to assess their balance. The test involved a star-shaped marking on the floor with eight directions (anterior, posterior, medial, lateral, anteromedial, anterolateral, posteromedial, and posterolateral), each separated by 45 degrees. Each participant placed one foot in the center of the star while reaching the opposite foot towards the specified directions. Participants were instructed to reach as far as possible in all eight directions. To minimize errors, each subject performed at least three trials.

Given the significant correlation between SEBT performance and leg length, measurements were taken from the anterior superior iliac spine (ASIS) to the medial malleolus after performing a pelvic bridging maneuver to apply joint distraction. The starting direction

and supporting leg for the SEBT were chosen randomly. The average reach distance from three trials was calculated for each direction.

Data collection involved recording the SEBT scores, leg length measurements, and demographic information. The data analysis was performed using SPSS version 25.0. Quantitative variables, such as age and SEBT scores, were presented as means and standard deviations. The comparison of balance between habitual high heel wearers and flat shoe wearers was evaluated using the Mann-Whitney U Test due to the non-normal distribution of the data. A p-value of 0.05 or less was considered statistically significant.

This study aimed to provide a comprehensive analysis of the impact of high heels and flat shoes on balance, contributing valuable insights to public health and ergonomics. The ethical conduct of the study was ensured by adhering to relevant guidelines and obtaining necessary approvals, ensuring the protection of participants' rights and well-being throughout the research process (1).

RESULTS

Table 1: Age of the Participants

	Minimum	Maximum	Mean	Std. Deviation
Age	18	35	23.83	3.430

Table 2: Comparison of Balance in High Heel Wearers and Flat Shoe Wearers

Direction	Group	N	Mean Rank	Sum of Ranks	P-value (Mann-Whitney U Test)
Anterior Reach Dominant Side	Heel wearers	21	27.50	577.50	0.031
	Flat shoe wearers	49	38.93	1907.50	
Anterior Reach Non-Dominant Side	Heel wearers	21	33.00	693.00	0.499
	Flat shoe wearers	49	36.57	1792.00	
Anteromedial Reach Dominant Side	Heel wearers	21	32.29	678.00	0.384
	Flat shoe wearers	49	37.88	1807.00	
Anteromedial Reach Non-Dominant Side	Heel wearers	21	36.02	756.00	0.887
	Flat shoe wearers	49	35.28	1728.00	
Medial Reach Dominant Side	Heel wearers	21	40.52	851.00	0.174
	Flat shoe wearers	49	33.30	1634.00	
Medial Reach Non-Dominant Side	Heel wearers	21	37.80	795.00	0.524
	Flat shoe wearers	49	34.49	1690.00	
Posteromedial Reach Dominant Side	Heel wearers	21	37.74	792.00	0.544
	Flat shoe wearers	49	34.48	1692.00	
Posteromedial Reach Non-Dominant Side	Heel wearers	21	35.90	754.00	0.913
	Flat shoe wearers	49	35.33	1731.00	
Posterior Reach Dominant Side	Heel wearers	21	34.10	716.00	0.704
	Flat shoe wearers	49	35.10	1769.00	
Posterior Reach Non-Dominant Side	Heel wearers	21	38.90	818.00	0.350
	Flat shoe wearers	49	34.02	1667.00	
Posterolateral Reach Dominant Side	Heel wearers	21	34.10	716.00	0.177
	Flat shoe wearers	49	36.10	1769.00	

Direction	Group	N	Mean Rank	Sum of Ranks	P-value (Mann-Whitney U Test)
Posterolateral Reach Non-Dominant Side	Heel wearers	21	38.99	818.00	0.934
	Flat shoe wearers	49	34.02	1667.00	

The results of this study revealed significant differences in balance between habitual high heel wearers and flat shoe wearers. The age of the participants ranged from 18 to 35 years, with a mean age of 23.83 years and a standard deviation of 3.430, indicating a relatively young and homogenous group (Table 1).

In terms of balance assessment using the Star Excursion Balance Test (SEBT), there were notable findings. For the anterior reach on the dominant side, high heel wearers had a mean rank of 27.50 compared to flat shoe wearers who had a mean rank of 38.93, with a p-value of 0.031. This suggests a statistically significant difference, indicating that flat shoe wearers exhibited better balance in this direction (Table 2). However, for the anterior reach on the non-dominant side, the mean rank for high heel wearers was 33.00, while flat shoe wearers had a mean rank of 36.57. The p-value of 0.499 indicates no significant difference between the two groups for this direction (Table 2).

When assessing the anteromedial reach on the dominant side, high heel wearers had a mean rank of 32.29, whereas flat shoe wearers had a mean rank of 37.88, resulting in a p-value of 0.384, showing no significant difference (Table 2). Similarly, for the anteromedial reach on the non-dominant side, high heel wearers had a mean rank of 36.02 compared to flat shoe wearers' mean rank of 35.28, with a p-value of 0.887, again indicating no significant difference (Table 2).

The medial reach on the dominant side showed that high heel wearers had a mean rank of 40.52, while flat shoe wearers had a mean rank of 33.30. The p-value of 0.174 suggests no significant difference (Table 2). For the medial reach on the non-dominant side, high heel wearers' mean rank was 37.80 compared to flat shoe wearers' mean rank of 34.49, with a p-value of 0.524, showing no significant difference (Table 2).

The posteromedial reach on the dominant side had high heel wearers with a mean rank of 37.74 and flat shoe wearers with a mean rank of 34.48, resulting in a p-value of 0.544, indicating no significant difference (Table 2). For the posteromedial reach on the non-dominant side, high heel wearers had a mean rank of 35.90, while flat shoe wearers had a mean rank of 35.33, with a p-value of 0.913, showing no significant difference (Table 2).

In the posterior reach on the dominant side, high heel wearers had a mean rank of 34.10, while flat shoe wearers had a mean rank of 35.10. The p-value of 0.704 indicates no significant difference between the two groups (Table 2). For the posterior reach on the non-dominant side, high heel wearers had a mean rank of 38.90, whereas flat shoe wearers had a mean rank of 34.02, resulting in a p-value of 0.350, showing no significant difference (Table 2).

Lastly, for the posterolateral reach on the dominant side, high heel wearers had a mean rank of 34.10 compared to flat shoe wearers' mean rank of 36.10, with a p-value of 0.177, indicating no significant difference (Table 2). For the posterolateral reach on the non-dominant side, high heel wearers had a mean rank of 38.99, while flat shoe wearers had a mean rank of 34.02, resulting in a p-value of 0.934, showing no significant difference (Table 2).

DISCUSSION

The results of this study revealed no significant differences in reach distances between habitual high heel wearers and flat shoe wearers across most directions of the Star Excursion Balance Test (SEBT), as determined by the Mann-Whitney U Test with p-values not less than 0.05. However, a significant difference was observed in the anterior reach distance, where the p-value was less than 0.05, indicating better performance by flat shoe wearers.

These findings contrast with some previous research. For instance, Jagger et al. (2020) found significant differences in the posterolateral and posteromedial reach directions between different balance tests but did not observe significant differences in the anterior reach direction (22). The current study, however, identified a significant disparity in the anterior reach, suggesting that high heel wearers may experience particular challenges in this direction that are not as apparent in other directions.

Another study conducted in 2019 focused on dynamic balance in workers frequently wearing high heels, including 28 subjects aged 21-45 years who wore high-heeled shoes of at least 5 centimeters for a minimum of 30 hours per week over one year. This study found a low SEBT score and a negative correlation with body weight and height, and a moderate positive correlation with ankle dorsiflexion range of motion (ROM). Interestingly, it did not find a relationship between the height of the high heels or the duration of wearing them per week and balance performance (23). These findings support the notion that habitual wearing of high heels may not significantly influence balance, aligning with the current study's results, except for the anterior reach direction.

The study's strength lies in its comprehensive approach, including a robust sample size and rigorous application of the SEBT across multiple directions. It also accounted for leg length differences, enhancing the reliability of the balance assessments. However, the

study faced limitations such as the exclusion of males, which may limit the generalizability of the findings. Additionally, the study relied on self-reported data regarding footwear habits, which could introduce recall bias.

A significant limitation was the inability to control for all potential confounding variables, such as individual differences in physical activity levels and other lifestyle factors that might influence balance. The cross-sectional design of the study also restricted the ability to infer causality. Future research should consider longitudinal studies to better understand the long-term effects of high heel wearing on balance and include a more diverse population to enhance the generalizability of the results.

The study concluded that while there was no significant difference in balance between habitual high heel wearers and flat shoe wearers in most SEBT directions, a notable exception was the anterior reach. The p-value for the anterior reach in habitual high heel wearers and flat shoe wearers was 0.031, indicating a significant difference, whereas p-values for other directions were greater than 0.05. These findings suggest that anterior balance may be more affected by high heel use, warranting further investigation into specific biomechanical and physiological factors that could explain this discrepancy.

CONCLUSION

The study concluded that while habitual high heel wearers and flat shoe wearers exhibited no significant differences in balance across most directions of the Star Excursion Balance Test, a significant difference was observed in the anterior reach direction. This suggests that high heel use may specifically impact anterior balance. The findings highlight the importance of considering footwear choices in public health discussions, as prolonged high heel use could pose balance challenges, potentially increasing the risk of falls and related injuries. Therefore, healthcare professionals should educate individuals about the potential impacts of high heels on balance and encourage the adoption of safer footwear practices to promote overall musculoskeletal health.

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