

EFFECT OF DIFFERENT FOOTWEAR TYPES AND SLEEPING DURATION ON FALL RISK AND POSTURAL STABILITY IN YOUNG ADULTS

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Abstract

Purpose: To assess the impact of different footwear and sleeping duration on postural stability and fall risk in young, healthy people.

Methods: Forty-eight participants (n = 44 females, 4 males) from Umm Al-Qura University students aged 20-30 years without lower extremity injury were tested for postural stability and fall risk tests under three footwear conditions: barefoot, wearing Saudi western sandals (Sharqi) for males and slippers for females, and wearing various types of socks on the Biodex Stability System™. Three trials of 20 seconds for each footwear type were completed.

Results: There were a statistically significant differences ($P < 0.05$) in the postural stability for barefoot and each of the following tests, thick socks ($P=0.002$), Slipper ($P=0.000$), and non-slip silicone socks ($P=0.000$). However, there were no significant differences in the postural stability between other types of footwear. There were statistically significant difference for the fall risk between barefoot and non-slip silicone socks ($P=0.016$) and no significant differences with other footwear. The results indicated no significant differences between Postural Stability or Fall risk for three sleep hours conditions.

Conclusion: Wearing specially designed footwear types improved balance, potentially reducing fall risk. However, sleep duration didn't significantly affect postural stability or fall risk.

Keywords: Saudi western sandals (Sharqi), Fall Risk, Postural Stability, Sleeping Duration, Biodex Stability System.

Introduction

Falls can cause serious injuries, including fractures and dislocations (1). Preventing falls is a crucial sign of high-quality medical attention. Wearing suitable footwear is one way to avoid it (2). The danger of falling is correlated with feet, shoes, and everyday activities. As the primary means of contact between feet and ground, shoes are essential for maintaining proper posture (3). Shoes have been demonstrated to impact balance, making them

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an essential aspect to consider while aiming to prevent falls (4).

Balance can be known as the capacity to stay upright, the capacity of an individual to keep their center of gravity (COG) inside the base of support (BOS) is known as postural stability, postural stability can be classified into two types: static, like being in stand position without any motion and dynamic, like walking. Many factors contribute to our balance and stability (5), although footwear is an important factor to maintain balance, both in static and dynamic, it is crucial for minimizing the risk of injuries (6). It also plays a vital role in preventing falls and contributes to protect our feet (7).

One of the main factors contributing to workplace and transportation-related deaths and injuries is sleep deprivation. Evidence indicates that everyone, including young and healthy people, is susceptible to both acute and chronic sleep deprivation in terms of postural balance, Paillard (8) stated that the effects of sleep deprivation on postural balance are exacerbated or emphasized by pathologies, age, and the circadian rhythm, it's because the affection of each instance; the vestibulo-ocular reflex, sensory reweighting, oculomotricity system sensitivity of visual perception, and visuospatial ability are all impaired affecting our balance system. So, we considered taking its effects on postural stability and fall risk.

our research contained various types of footwear such as: thick socks, silicone socks, Saudi western sandals "sharqi" for males and slippers for females, we tested each footwear through two standardized types of tests; postural stability and fall risk tests using Biodex balance system machine. The Biodex balance system (BBS) is an evaluation tool for stability in a variety of populations, the (BBS) has lately drawn interest from the balance training field, since there is only a little amount of published data about its use is available, it is a relatively new device (9). Thus, the purpose of this study was to assess the impact of different footwear and sleeping duration on postural stability and fall risk in young, healthy people.

Materials and Methods

Study Design: This was a repeated measures study.

Participants

Forty-eight participants (n = 44 females, 4 males) were selected from Umm Al-Qura University students. The study included students aged 20-30 years with normal BMI. Those with abnormal BMI or any lower extremity musculoskeletal or neurological impairments were excluded. Informed consent was obtained

from all participants prior to their participation. This study protocol was reviewed and approved by the ethical committee, Umm Al-Qura University (HAPO-02-K-012-2023-12-1915).

Methods

A single group repeated measures design was used. Each participant underwent both postural stability and fall risk tests using Biodex balance system. It's an affordable, reliable platform that is used to evaluate balance in various populations (10), under three footwear conditions: [1] barefoot, [2] wearing Saudi western sandals (Sharqi) for males and slippers for females and [3] wearing various types of socks (thick, non-slip silicon socks). The order of testing was randomized to prevent any potential order effects. Additionally, we aimed to investigate any possible relationship between balance and sleeping habits. As part of the sample characterization process, we will initially collect information on participants' names, ages, heights, weights, and BMIs. All participants will be asked to complete a questionnaire regarding their sleep patterns.

Footwear

Subjects were evaluated barefooted as well as with three different types of footwears. The selection of footwear in this study was focused on types commonly used in the Kingdom of Saudi Arabia, which are Saudi western sandals (Sharqi) for males and (slippers) for females, thick socks, and non-slip silicon socks (Figure1).

Balance Testing

The Biodex Balance Stability System (Biodex Medical Systems, Shirley, New York, USA), featuring a circular platform functioning as a conventional force plate, was utilized for balance assessment by calculating anteroposterior (AP), mediolateral (ML) and overall (OA) indices. There are 12 levels of stability, with level 1 being the most volatile and level 12 being the most stable level (11). In this study, the indices were computed during both the postural stability test at platform stability level 6 and the fall risk test from platform stability levels 12 to 6. Throughout the assessments, subjects were tested with their eyes open.

Procedures

Postural stability assessment

Participants will stand on the Biodex balance locked platform, to assess the



Figure 1. The test footwear types used in the study. (a) Saudi western sandals (Sharqi) for males; (b) Slippers for females; (c) Thick socks; (d) non-slip silicon socks

feet position coordination and establish the ideal feet positioning for testing. The platform will be unlocked to allow movement. Subjects were instructed to adjust the feet position unit, they find a position at which they can maintain platform in ideal position. The platform is locked, and the feet position coordination will be recorded; the feet position is constant throughout the tests. It contains 3 trials, When the test begin, the platform is released for 20 seconds and subjects were asked to maintain an upright position standing for calculating anteroposterior (AP), mediolateral (ML) and overall (OA) indices of postural stability test at platform stability of level 6, and rest for 10 seconds between trials (12).

Participants were asked to complete the test barefooted, and with wearing thick socks and non-slip silicone socks, Saudi Western sandals (sharqi) for men and as an alternative, slippers for women.

Falls Risk Assessment

Fall risk was measured by using the Biodex Balance unlocked platform. The participants stood on the unlocked platform to allow movement with bare feet and different footwear types, including Saudi western sandals (Sharqi) for males, slippers for females, and different types of socks (thick and non-slip silicone socks). The feet are supposed to be adjusted by participants until they discover a position where they are able to maintain the platform in the optimal position. To calculate the total stability index of the fall risk test at platform stability levels 12 to 6, the platform is released for 20 seconds at the start of the test, and participants must remain in an upright position. Low results on these tests suggest the participant is steady, while high results suggest an imbalance and a greater risk of falling (13).

Tested participants always keep their eyes open. Utilizing the foot's midline and the platform's grid as reference points, the locations of the left foot, left heel, right foot, and right heel will be documented. During the test, the feet' position remains unchanged. The platform is unlocked, the lever is raised, and the coordination of the foot position was recorded.

Questionnaire

A self-questionnaire was utilized with participants, which included basic information like name, age, height, weight, gender, BMI, and the sleep length has been classified into three categories: short (<7 hours), average (7-8 hours), and long (>8 hours) (14).

Finally, a brief inquiry was posed concerning about the participants' preferred footwear.

Statistical Analysis

The data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) version 25. The mean and standard deviation (SD) were calculated for all demographic characteristics including age, height, weight, and

BMI. Prior to inferential analysis, all data underwent exploration for normality using Shapiro-Wilk test to ensure adherence to assumptions. To assess significant differences among the three footwear conditions [1] barefoot, [2] wearing Saudi western sandals (Sharqi) for males and slippers for females, and [3] wearing various types of socks (thick, non-slip silicon socks), Wilcoxon Signed Ranks tests were employed. These non-parametric tests were chosen due to potential violations of normality. The level of balance was evaluated in both Postural stability and Fall risk tests. Furthermore, the influence of sleep hours on balance was investigated using Kruskal-Wallis tests. This allows the determination of significant differences in balance level across varying sleep durations. For all tests conducted, the alpha level was set at $P < 0.05$ to determine statistical significance.

Results

The anthropometric characteristics of study volunteers

The 48 participants in this study were (n = 44 females, 4 males) with an overall mean (SD) of age, height, weight, and BMI were 21.08(0.86), 157.40(6.48), 54.31(6.82), 21.87(1.97) respectively, (Table 1). Flow Chart of the study design, (Figure 2).

The postural Stability index for three footwear conditions

The results from Wilcoxon Signed Ranks test confirmed a significant differences ($p < 0.05$) between the level of balance in the Postural stability test for Barefoot and each of the following tests, Thick socks ($p=0.002$), Slipper ($p=0.000$), Non-slip silicone socks ($p=0.000$). However there were no significant differences in the Postural stability test between (Thick Socks * Slipper, Thick Socks * Non-slip silicone socks, and Slipper * Non-slip silicone socks) could be seen at (Table 2).

The fall risk test index in degrees for three footwear conditions

The results from Wilcoxon Signed Ranks test confirmed a significant differences ($p < 0.05$) between the level of balance among Umm Al-Qura University students on the Fall risk test between Barefoot and Non-slip silicone

Table 1. Anthropometric characteristics of study volunteers.

Variable	Mean (SD)	Mean (SD)	Mean (SD)
	Female (n= 44)	Male (n=4)	All (N=48)
Age (years)	21.11(0.86)	20.75(0.95)	21.08(0.86)
Height (Cm)	156.41(5.40)	168.25(9.03)	157.40(6.48)
Weight (Kg)	53.25(6.01)	66.00(5.35)	54.31(6.82)
Body Mass Index (BMI)	21.74(1.95)	23.37(2.00)	21.87(1.97)

Values are numbers (n) or mean SD: standard deviation

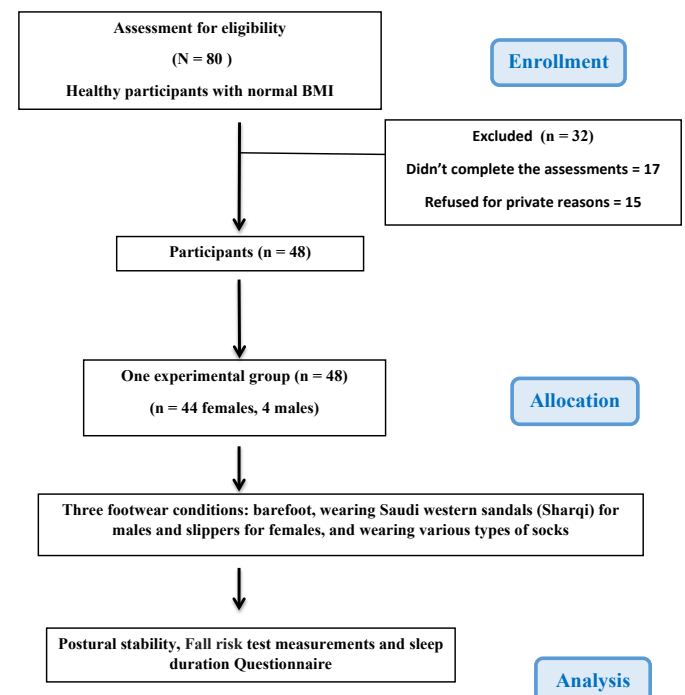


Figure 2. Flow Chart of the study design.

Table 2. Postural Stability index in degrees for three footwear conditions.

Postural Stability Test		Mean (SD)	Z	Sig
Barefoot * Thick Socks	Barefoot	0.88(0.29)	3.13	0.002*
	Thick Socks	0.77(0.23)		
Barefoot * Slipper	Barefoot	0.88(0.29)	3.697	0.000*
	Slipper	0.72(0.22)		
Barefoot * Silicone	Barefoot	0.88(0.29)	3.747	0.000*
	Silicone	0.74(0.22)		
Thick Socks * Slipper	Thick Socks	0.77(0.23)	1.587	0.112**
	Slipper	0.72(0.22)		
Thick Socks * Silicone	Thick Socks	0.77(0.23)	0.998	0.318**
	Silicone	0.74(0.22)		
Slipper * Silicone	Slipper	0.72(0.22)	0.976	0.329**
	Silicone	0.74(0.22)		

SD: standard deviation * = significant ** = non-significant

Table 3. Fall risk test index in degrees for three footwear conditions.

Fall risk test		Mean (SD)	Z	Sig
Barefoot * Thick Socks	(Barefoot)	0.75(0.34)	1.545	0.122**
	Thick Socks	0.70(0.28)		
Barefoot * Slipper	Barefoot	0.75(0.34)	0.805	0.421**
	Slipper	0.71(0.34)		
Barefoot * Silicone	Barefoot	0.75(0.34)	2.41	0.016*
	Silicone	0.64(0.23)		
Thick Socks * Slipper	Thick Socks	0.70(0.28)	0.184	0.854**
	Slipper	0.71(0.34)		
Thick Socks * Silicone	Thick Socks	0.70(0.28)	1.589	0.112**
	Silicone	0.64(0.23)		
Slipper * Silicone	Slipper	0.71(0.34)	1.36	0.174**
	Silicone	0.64(0.23)		

SD: standard deviation * = significant ** = non-significant

socks ($p=0.016$) and no significant differences with other footwear (Thick socks, Slipper) could be seen at (Table 3).

The effects of three sleep hours conditions

The results from Kruskal-Wallis test was conducted to determine if there were significant differences in the level of balance among Umm Al-Qura University students based on the sleep hours variable, the results indicated no significant differences between Postural Stability and Fall risk index in degrees for three sleep hours conditions at ($p < 0.05$) presented in (Table 4).

Discussion

This study aimed to examine the effects of different types of footwear and sleep duration on postural stability and fall risk tests in young healthy adult's females and males of Umm Al-Qura University.

The findings of the current investigation indicated that the postural stability was enhanced during wearing various types of footwear such as slippers, thick socks and non-slip silicone socks compared to being barefooted with the best stability with slippers, this agreed with Rodríguez et al. (2) who recommended to wearing appropriate footwear to prevent falls on the ground and this could be explained by Alghadir et al. (3) who stated that shoes are essential for maintaining proper posture as they were the primary means of contact between feet and ground. The danger of falling is correlated with feet, shoes, and everyday activities. However, wearing a slipper compared to thick socks and non-slip silicone socks did not have any significant changes in postural stability.

Our findings suggested that wearing non-slip silicone socks and slipper improved the postural stability compared to other conditions. Also, our results were supported by Smith et al. (15) who concluded that wearing vibram five fingers or being barefoot did not improve postural stability as much as wearing an athletic shoes, OA and AP static balance were improved by wearing vibram five fingers compared to being barefooted, although static balance in vibram five fingers would be similar to that in bare feet. Our research findings were encouraged by Menz et al. (16) who studied 3 types of footwear: socks, backless slipper and enclosed slipper. Their results depended on, walking speed, cadence, and step length measurements, their results showed that the

Table 4. Postural Stability and Fall risk index in degrees for three sleep hours' conditions.

The Test	Sleep Hours	Mean (SD)	Z	Sig
Postural Stability Test (Barefoot)	Less than 7	0.95(0.35)	2.007	0.367**
	7 to 8	0.86(0.279)		
	More than 8	0.77(0.206)		
Postural Stability Thick Socks	Less than 7	0.71(0.226)	2.752	0.253**
	7 to 8	0.82(0.236)		
	More than 8	0.73(0.236)		
Postural Stability Slipper	Less than 7	0.65(0.194)	5.097	0.078**
	7 to 8	0.79(0.225)		
	More than 8	0.66(0.237)		
Postural Stability Silicone	Less than 7	0.74(0.223)	0.086	0.958**
	7 to 8	0.75(0.223)		
	More than 8	0.74(0.237)		
Fall Risk Test (Barefoot)	Less than 7	0.65(0.184)	2.61	0.271**
	7 to 8	0.85(0.424)		
	More than 8	0.69(0.273)		
Fall Risk Test Thick Socks	Less than 7	0.66(0.260)	1.588	0.452**
	7 to 8	0.75(0.304)		
	More than 8	0.61(0.254)		
Fall Risk Test Slipper	Less than 7	0.67(0.342)	1.859	0.395**
	7 to 8	0.77(0.356)		
	More than 8	0.64(0.321)		
Fall Risk Test Silicone	Less than 7	0.59(0.228)	2.732	0.255**
	7 to 8	0.69(0.238)		
	More than 8	0.60(0.245)		

SD: standard deviation * = significant ** = non-significant

best gait patterns and balance occurred when wearing the enclosed slippers, intermediate results when wearing backless slippers, and the worst results while wearing socks. Findings suggest that enclosed slippers may be the most appropriate footwear for older women with an increased risk of falling. In contrast to the previous, Alghadir et al. (3) found that in healthy young adult males, wearing a sandal considerably increased postural sway and decreased stability when compared to bare feet.

The results of our current study appeared that there was a significant difference between bare feet and non-slip silicone socks in the fall risk test and not significantly difference with other conditions, so wearing the non-slip silicone socks could reduce the risk of fall in the participants.

Reduced sleep duration and quality, increases weariness, impairs productivity at work, reduces physical activity, and may cause balance issues (17). Although our research outcomes demonstrated that there were no significant differences between postural stability and fall risk individual's sleeping hours either male or female, a previous study by Ołpińska-Lischka et al. (18) found that there is a difference between the two genders although the men faced a deterioration in their postural stability unlike women, their sleep hours did not affect their postural control at all. In contrast to our findings, Paillard (8) stated that the sleep deprivation affects our postural balance.

Conclusion

The tested footwear types improved postural balance in young healthy people compared to being barefooted. The non-slip silicone socks could reduce the fall risk in healthy young adults. Regarding the sleep hours duration, the results of the present study showed no significant differences for Postural Stability and Fall risk index between the three sleep hours conditions. Additionally, there was no significant differences for Postural Stability and Fall risk index between males and females.

Recommendations

- Wearing the non-slip silicone socks could reduce the risk of fall in the participants.
- For more challenging situations, modify the platform stability level to level 1 for both postural stability and fall risk
- To enhance the result generalization, we recommend increasing the number of participants in these tests.

Ethical approval: This protocol received approval from the "Biomedical

Ethics Committee at Umm Al Qura University, Saudi Arabia (HAPO-02-K-012-2023-12-1915).

Conflict of interest: None

Author contributions

All authors contribute in concept and design of the study, data analysis, critical revision of the manuscript and final approval of the version to be submitted

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