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FOOT POSTURE AND ITS ASSOCIATION WITH BALANCE FUNCTION IN GERIATRIC POPULATION

Original Research

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Acknowledgment: We sincerely thank the participants, healthcare staff, and supporters for their contributions to this study.

Conflict of Interest: None
Grant Support & Financial Support: None

ABSTRACT

Background: Foot posture plays a critical role in balance and functional mobility, particularly in the geriatric population. Aging is associated with changes in foot posture, which may lead to balance impairments, increased risk of falls, and reduced quality of life. Understanding the distribution of foot posture types and their relationship with balance function is essential for developing interventions to improve stability in older adults.

Objective: To determine the prevalence of foot posture types and their association with balance function in the geriatric population.

Methods: A cross-sectional study was conducted in Hayatabad, Peshawar, from March 2, 2022, to September 3, 2022. A total of 196 participants aged 60 years and above were recruited through non-probability convenience sampling. Participants were included based on predefined eligibility criteria and provided informed consent. Data collection involved demographic details, medical history, and assessments using the Foot Posture Index (FPI) to classify foot posture into neutral, pronated, highly pronated, supinated, or highly supinated. Static balance was evaluated using the Berg Balance Scale (BBS), with scores ranging from 0–56. Data analysis was performed using SPSS version 22, employing descriptive statistics and chi-square tests to determine associations.

Results: The study included 95 males (48.5%) and 101 females (51.5%), with a mean age of 69.07 ± 6.59 years. Pronated foot posture was the most prevalent (39.3%), followed by neutral (32.1%), supinated (17.9%), highly pronated (9.2%), and highly supinated (1.5%). Pronated foot posture was significantly more common in females (47.5%), while supinated foot posture was more prevalent in males (21.1%). Participants with pronated foot posture had higher BBS scores, with 47.9% scoring 51–56, compared to 32.9% of those with neutral posture. Conversely, 43.3% of participants with supinated foot posture had lower BBS scores in the range of 41–45. A significant association ($p<0.05$) was observed between foot posture and BBS scores, as well as between foot posture and gender.

Conclusion: Pronated foot posture is the most common type in older adults, followed by neutral and supinated postures. Pronated foot posture is associated with better static balance, as indicated by higher BBS scores, while supinated foot posture correlates with lower scores, reflecting poorer balance. These findings highlight the importance of foot posture assessments in geriatric evaluations to address balance impairments and reduce fall risks.

Keywords: Activities of daily living, aged, balance, foot deformities, foot posture, older adults, postural stability.

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INTRODUCTION

The foot plays a pivotal role in human ambulation, serving as the primary point of contact with the ground during weight-bearing activities such as walking, running, and jumping. It functions as a critical shock absorber and adapts to uneven surfaces, ensuring stability and mobility (1). In the geriatric population, significant changes in foot posture (FP) are frequently observed, with foot-related problems increasing markedly with advancing age (2, 3). Alterations in FP can predispose older adults to injuries during physical activities and impact their overall quality of life (1, 4). Conditions such as pronated and supinated FP often emerge later in life when skeletal maturity is complete. Factors such as ligamentous laxity, ill-fitting footwear, and inadequate podiatric care contribute to the development of deformities like flatfoot or pes planus (2, 5, 6). Supinated FP, characterized by an elevated medial longitudinal arch, presents unique clinical challenges due to the subtle nature of its associated pain, which often goes undetected or untreated (5, 7). Many individuals with foot deformities remain asymptomatic, further decreasing the likelihood of seeking timely medical intervention (5, 7).

Foot deformities, whether congenital or acquired, significantly affect balance, increase the risk of falls, and impair daily activities in older individuals (8). Neutral FP, with its normal anatomical structure and robust ligaments, provides superior postural stability, whereas pronated and supinated FP are associated with biomechanical alterations. Pronated FP involves a flattened medial arch, calcaneal eversion, and forefoot valgus, while supinated FP, or high-arched feet, is characterized by calcaneal inversion and forefoot varus (9). Epidemiological studies suggest that 23% to 60% of individuals with supinated FP report foot pain, with this deformity affecting up to 50% of older adults, particularly males (1, 7). Risk factors for FP changes include age, sex, obesity, comorbidities, and the prolonged use of improperly fitted footwear, as well as structural foot disorders such as hallux valgus and hammer toes (3). In females, pronated FP is more common, especially in those over 65, whereas supinated FP has a higher prevalence in males above 75 years (11, 12). Aging-related changes, including wider, flatter feet and diminished fat padding, further exacerbate foot-related discomfort and functional impairments (3, 14). Pronated FP can also contribute to low back pain, particularly in females, due to increased stress on the lumbopelvic region during walking (15).

The implications of altered FP on balance are profound. Older adults with pronated FP face increased risks of falls, balance disturbances, and impaired gait performance, as these conditions alter muscle activity in the tibialis anterior and posterior during gait phases, disrupting postural stability (16, 17, 18). Supinated FP, characterized by larger center-of-pressure excursions, has been linked to ankle instability and increased susceptibility to lateral ankle sprains (9, 22). Similarly, low-arched feet are associated with higher odds of toe deformities such as hammer toes, overlapping toes, and plantar fasciitis, while pronated FP has been identified as a risk factor for conditions like tailor bunion and Morton's neuroma (10, 24, 25, 26, 27). The intersection of these deformities with age-related musculoskeletal changes underscores the need for further investigation into their impact on balance and functional mobility in older adults.

The objective of this study is to explore the association between foot posture and balance function in the geriatric population, aiming to provide insights that may guide clinical assessment and management strategies for improving postural stability and reducing fall risk among older individuals.

METHODS

The study employed a cross-sectional survey design and was conducted in Hayatabad, Peshawar. After obtaining approval from the relevant institutional review boards, including the Graduate Committee (GC) and the Advance Research and Study Board (ASRB) of KMU Peshawar, the research spanned a duration of six months. The sample size was determined using the OpenEpi sample size calculator (www.openepi.com), and 196 participants were included based on the following assumptions: an anticipated frequency of 15% with a 95% confidence level. A non-probability convenience sampling technique was used for participant recruitment.

Participants were assessed for eligibility based on predefined inclusion and exclusion criteria. Eligible participants included community-dwelling older adults aged 60 years and above, both male and female, who were capable of walking independently over a distance of 10 meters without the use of walking aids and had a Berg Balance Scale (BBS) score above 40. Exclusion criteria included individuals with foot symptoms such as pain, swelling, or loss of sensation, known cases of osteoarthritis, recent fractures or surgeries of the lower limb,

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total knee replacements, open foot wounds, skin infections, diabetes, or other vestibular and balance disorders to minimize confounding factors. The inclusion of a BBS score above 40 ensured participant safety during the evaluation process and focused on individuals with sufficient functional mobility to complete the tasks. However, this criterion may have limited the generalizability of the findings by excluding older adults with more pronounced balance impairments, potentially skewing the results toward individuals with moderate to good balance.

Informed consent was obtained from all participants after providing detailed information about the study through a written information sheet. Participants who were unable to comprehend the written sheet were provided with verbal explanations to ensure clarity. Consent was confirmed through both signed documentation and verbal agreement. Data collection included demographic information, medical history, and a detailed screening process to verify eligibility. Participants were selected from normal, healthy, community-dwelling older adults in the designated region.

Foot posture was assessed using the Foot Posture Index (FPI), which classifies foot posture into five categories: normal or neutral, pronated, hyperpronated, supinated, and hypersupinated. FPI scores ranged from 0 to ±12. Balance was evaluated using the Berg Balance Scale (BBS), a standardized tool comprising 14 tasks of varying complexity, such as sitting-to-standing, standing unsupported, and tandem stance, culminating in tasks like standing on one leg. The BBS scores range from 0 to 56, with a score of 41–56 indicating normal balance, 20–40 suggesting a high risk of falls, and 0–20 indicating significant balance impairment.

Data analysis was conducted using SPSS version 22. Descriptive statistics were employed to summarize participant demographics and baseline characteristics. Associations between categorical variables were analyzed using the chi-square test.

RESULTS

A total of 196 participants were recruited for the study, with a mean age of 69.07±6.59 years. The sample comprised 95 males (48.5%) and 101 females (51.5%). Among the age group 60–70 years, 55 were males (46.2%) and 64 were females (53.8%), while in the 71–80 years category, 32 were males (51.6%) and 30 were females (48.4%). The oldest group, aged 81–90 years, included 8 males (53.3%) and 7 females (46.7%). The mean Foot Posture Index (FPI) was recorded as 4.13±3.08, indicating varying foot postures across participants. The mean Berg Balance Scale (BBS) score was 49.14±3, with 15.3% of participants scoring 41–45, 47.4% scoring 46–50, and 37.2% scoring 51–56, showing a distribution of balance abilities across the sample.

Regarding foot posture, 63 participants (32.1%) exhibited neutral FP, 77 (39.3%) showed pronated FP, 18 (9.2%) displayed highly pronated FP, 35 (17.9%) had supinated FP, and 3 (1.5%) showed highly supinated FP. Pronated FP was more prevalent among females (47.5%), while supinated FP was more common among males (21.1%). A significant association ($p<0.05$) was observed between gender and foot posture, indicating a higher tendency of females toward pronated FP and males toward supinated FP. Additionally, age was significantly associated with FP. In the age group 60–70 years, 47.9% displayed pronated FP, while 40% of participants aged 81–90 years exhibited supinated FP.

A significant relationship ($p=0.001$) was also found between FP and BBS scores. Participants with pronated FP demonstrated better balance, with higher BBS scores predominantly in the 46–50 and 51–56 categories. Conversely, supinated FP was associated with lower balance scores, as 43.3% of participants with supinated FP had BBS scores in the 41–45 range, indicating poor balance performance. These findings highlight the critical impact of foot posture on balance function in older adults.

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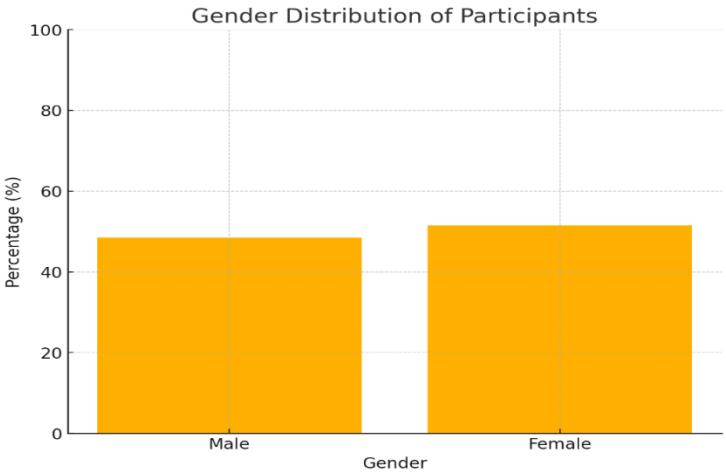


Figure 1 Gender Distribution of Participants

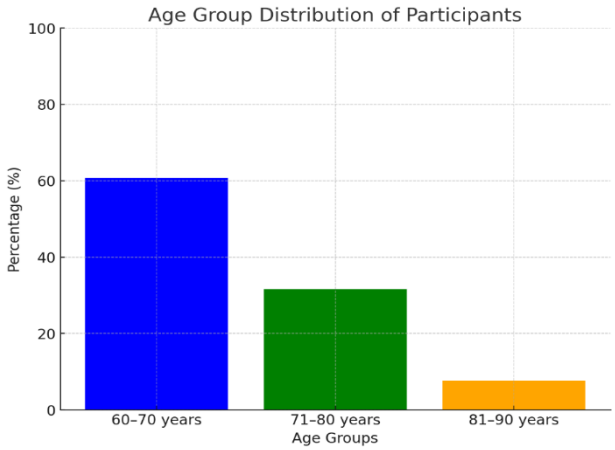


Figure 2 Age Group Distribution of Participants

Table 1 Demographic Characteristics, Foot Posture, and Balance Scores of Participants

Demographic/Variables	**Number (Percentage)**
Total Participants	196 (100%)
Mean Age (years)	69.07 ± 6.59
Gender	
- Males	95 (48.5%)
- Females	101 (51.5%)
Age Groups	
- 60–70 years	119 (60.7%)
- 71–80 years	62 (31.6%)
- 81–90 years	15 (7.7%)
Foot Posture	
- Neutral	63 (32.1%)
- Pronated	77 (39.3%)
- Highly Pronated	18 (9.2%)
- Supinated	35 (17.9%)
- Highly Supinated	3 (1.5%)
BBS Score	
- 41–45	30 (15.3%)
- 46–50	93 (47.4%)
- 51–56	73 (37.2%)

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This table summarizes the demographic details, foot posture distribution, and Berg Balance Scale (BBS) scores of the 196 participants. The majority of participants were aged 60–70 years, with a nearly equal gender distribution. Pronated foot posture was the most common, while highly supinated posture was the least observed. Most participants demonstrated good balance, with a BBS score between 46–50.

DISCUSSION

The study was conducted on community-dwelling older adults aged 60 years and above, with a total of 196 participants, comprising 95 males and 101 females. The primary objective was to evaluate the frequency of foot posture (FP) in this population and its association with static balance. Foot posture was assessed using the Foot Posture Index (FPI), which has been recognized as a reliable and efficient tool for evaluating foot position in both clinical and research settings (Anthony et al., 4). Static balance was measured using the Berg Balance Scale (BBS), a validated instrument designed to evaluate balance in older adults, including individuals with varying degrees of physical limitations. This study identified pronated FP as the most prevalent condition, followed by supinated FP, with a significant association between FP and age ($p=0.007$). Participants in younger age groups exhibited a higher prevalence of pronated FP, while supinated FP was more common in the older age groups, suggesting age-related variations in foot posture.

The study results revealed a significant association between FP and gender, with females displaying a higher prevalence of pronated FP and males exhibiting a greater tendency toward supinated FP. This finding aligns with prior research indicating that gender-related anatomical and biomechanical differences influence foot posture patterns in older adults (27). In contrast, previous studies reported a relatively balanced prevalence of flatfoot posture between males and females, emphasizing the need to contextualize results within demographic and methodological differences. The observed association between FP and BBS scores further highlighted the relationship between foot biomechanics and balance. Pronated FP was associated with higher BBS scores, supporting earlier studies suggesting that an increased contact area with the ground in flatfoot postures may enhance postural stability. Conversely, supinated FP was linked to lower BBS scores, indicating compromised static balance, which is consistent with previous findings suggesting that high-arched feet may negatively impact weight-bearing stability (6).

The strengths of this study include its use of validated assessment tools and its focus on a community-dwelling geriatric population, which enhances the clinical relevance of the findings. However, the inclusion of participants with a BBS score above 40 may have excluded individuals with more pronounced balance impairments, potentially limiting the generalizability of the results. Additionally, the cross-sectional design precludes the establishment of causation, and further longitudinal studies are warranted to explore the dynamic relationship between FP and balance changes over time. The study also lacked an examination of comorbidities, such as diabetes and osteoarthritis, which could influence foot posture and balance outcomes.

A recent comparative study conducted by Lee et al. (2021) investigated the relationship between foot posture and balance in older adults, comparing participants with pronated, neutral, and supinated foot types. The study included 220 community-dwelling individuals aged 60 years and above, utilizing the Foot Posture Index (FPI) and Berg Balance Scale (BBS) for assessment. Results indicated that participants with pronated feet exhibited significantly higher BBS scores compared to those with supinated feet, supporting the hypothesis that increased foot contact with the ground enhances postural stability. Supinated foot posture, on the other hand, was associated with decreased BBS scores, reflecting poorer balance and higher risk of falls. This study strengthens the current findings by confirming the relationship between foot posture and balance while emphasizing the necessity of targeted interventions for individuals with supinated foot posture to reduce fall risk and improve functional outcomes (28).

This study reinforces the role of foot posture in determining balance function among older adults. While pronated FP was associated with better balance performance, supinated FP demonstrated a propensity for lower BBS scores, emphasizing the need for targeted interventions to address foot posture abnormalities in geriatric populations. These findings highlight the importance of incorporating foot assessments and appropriate management strategies into geriatric care to improve postural stability and reduce the risk of falls. Future research should focus on expanding the scope of analysis by including participants with significant balance impairments and exploring the impact of specific interventions on foot posture and balance outcomes.

CONCLUSION

The findings of this study highlight that pronated foot posture is the most common type in the geriatric population, followed by normal and supinated postures. Pronated foot posture was notably more prevalent among females, demonstrating a significant association

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between foot posture, age, and gender. Furthermore, the study established that pronated foot posture was linked to better balance performance, as indicated by higher scores on the Berg Balance Scale, while supinated foot posture was associated with poorer balance outcomes. These results underscore the importance of assessing foot posture as a critical component of evaluating balance function in older adults, which could aid in the development of targeted interventions to enhance stability and reduce the risk of falls in this vulnerable population.

AUTHOR CONTRIBUTIONS

Author	Contribution
Iqra Mubeen	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Ruqayyah	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Sara Qureshi	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Rafia Imtiaz*	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

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