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# Correlation of Foot Posture, Dynamic Balance and Gait Speed in Community-dwelling Older Individuals

**Ankita Vinodbhai Lakhmani[1], Dharti Shah[2]**

[1]M.P.T Student, [2]Assistant Professor, Ph.D. Scholar;
Apollo Institute of Physiotherapy, SNME Campus, Enasan, Ahmedabad, India

Corresponding Author: Ankita Vinodbhai Lakhmani

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## ABSTRACT

**Introduction:** Foot posture is crucial in maintaining stability and balance during movement. It encompasses the position and alignment of the feet and ankles, significantly impacting overall body stability and reducing the risk of falls. Dynamic balance refers to maintaining balance while in motion, encompassing walking, running, and jumping.
**Aim:** To find a correlation between foot posture, dynamic balance and gait speed in community-dwelling older individuals.
**Materials and Methods:** The correlational study included 100 community-dwelling older individuals who met the specified inclusion and exclusion criteria. The Foot Posture Index was utilised as the outcome measure for foot posture, the Modified Four-Square Step Test (MFSST) for dynamic balance, and the Gait Speed Test for gait speed assessment.
**Results:** The results revealed a weak positive correlation between gait speed and foot posture, with a statistically significant weak positive correlation observed in individuals with normal foot posture. In contrast, a statistically significant moderate positive correlation was found between gait speed, dynamic balance, and pronated foot posture ($r= 0.63$, $P < 0.05$). Furthermore, a weak negative correlation was observed between gait speed and supinated foot posture, with a statistically significant moderate negative correlation between dynamic balance and supinated foot posture.
**Conclusion:** Pronated foot posture demonstrated a stronger association with gait speed and dynamic balance than supinated and normal foot posture. These findings suggest that older adults with pronated foot posture experience greater effects on gait speed and dynamic balance.

***Keywords:*** Foot posture, Gait, Balance, Elderly

## INTRODUCTION

The ageing process brings about numerous changes in the human body, including alterations in musculoskeletal and physiological systems. Among these changes, alterations in foot posture, dynamic balance, and gait speed are particularly significant in older individuals, as they directly impact mobility, independence, and overall quality of life. Understanding the interplay between these factors is essential for designing effective interventions to promote healthy ageing and prevent falls, a major concern among community-dwelling older individuals. [1,2,3]
Foot posture refers to the alignment and positioning of the foot's anatomical structures, including the arches, joints, and tendons. With age, there is a tendency for the foot's arches to flatten, leading to changes in foot mechanics and potential biomechanical imbalances.[4] These changes can affect the foot's structural integrity and its role in providing stable support during activities such as standing and walking. [5]
On the other hand, dynamic balance is the ability to maintain equilibrium while performing tasks involving movement. It

relies on integrating sensory information from the visual, vestibular, and proprioceptive systems and coordinated muscular responses. As individuals age, there is a decline in sensory processing and muscle strength, which can compromise dynamic balance and increase the risk of falls. [6]

Gait speed, a fundamental aspect of mobility, reflects an individual's ability to walk efficiently and safely.[7] Slower gait speed is commonly observed in older adults and has been associated with various negative outcomes, including reduced functional independence, increased risk of falls, and a decline in overall health. Various factors influence it, including muscle strength, joint function, balance control, and cognitive processing. [7,8]

This study explores the correlation between foot posture, dynamic balance, and gait speed in community-dwelling older individuals. By examining these relationships, we seek to contribute to the body of knowledge that informs evidence-based strategies for enhancing functional capacity and reducing fall risk in the ageing population.

## MATERIALS & METHODS

In the study, individuals were assessed for their eligibility using specific inclusion and exclusion criteria. Those eligible for participation could be of both genders and had to fall within the age range of 60 to 80 years. Additionally, they needed to have been capable of walking a minimum distance of 10 meters, whether with or without assistive devices.

Conversely, individuals who met any of the following exclusion criteria were not considered for participation: a recent lower limb injury or surgical procedure within the last six months, experiencing pain or having an orthopedic condition in both legs, a history of neurological conditions, visual impairments, or vestibular disorders, and engagement in any form of gym activities or physical therapy within the past 6 months.

### OUTCOME MEASURES

1. **Foot posture index (FPI):**

- The Foot Posture Index (FPI) is a clinical diagnostic tool to quantify the static posture of the foot. It is a simple and rapid method and has demonstrated good reliability. It comprises six criteria that measure the degree of neutral, pronated, or supinated posture. Its full assessment requires only approximately 2 min and no special equipment. It is performed in the three body planes and provides information on the hindfoot, midfoot, and forefoot. [9]
- These are the six criteria of the Foot Posture Index:

**Talar head position**

**Supra and infra lateral malleolar curvature**

**Calcaneal frontal plane position**

**Prominence in the region of the talonavicular joint**

**Height and congruence of the medial longitudinal arch**

**Abduction/adduction of the forefoot on the rear foot**

**2. Modified four square step tests:**

- The Modified Four-Square Step Test (mFSST) is a mobility assessment tool often used to assess an individual's dynamic balance and functional mobility. Modifying the test for older adults is important to ensure its appropriateness and safety for this population. It requires a stopwatch and masking tape in a cross formation on the floor. 2 trials are performed, and the best time is recorded.

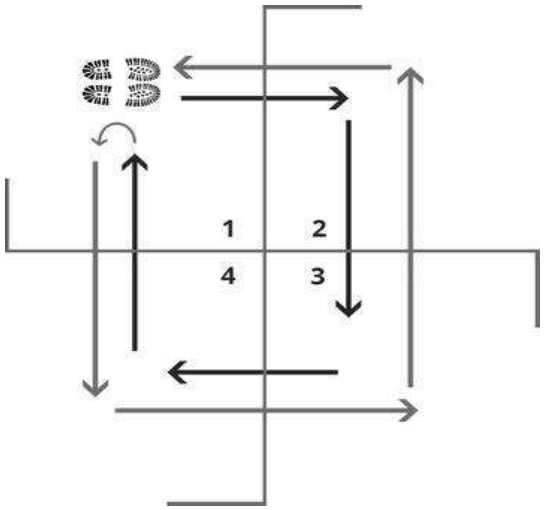


**Figure:1 Modified Four-Square Step Test**

- **General information to give the patient:**
  The patient is instructed to stand in square 1 facing square number 2
  The patient is required to step as fast as possible into each square in
  the following sequence: 2, 3, 4, 1, 4, 3, 2, and 1 requires the patient to step forward, backward, and sideways to the right and left
- Equipment required for the mFSST includes a stopwatch and masking tape. [10]

**3. Gait Speed Test:**

- It is used to assess patient's gait speed and ability to accelerate and decelerate. Diminished gait speed can be a poor marker of health. Slow gait speed is the single best predictor of functional decline and disability. Gait speed predicts falls, ADL ability and potential for community living.

**Equipment: masking tape and ruler.**

- Measure a standard distance (6 meters), and place a marker at the start and finish. Start the patient 5 ft in front of the start marker, and have them walk until they are one past the finish marker to account for acceleration and deceleration. Instruct pt to walk at their preferred walking speed. Begin timing when the first foot crosses the start line and stop timing when the second foot crosses the finish line. Assistive devices may be used. Practice trial and then two trials may be given, and use the best performance of two. [11]

## PROCEDURE

This study obtained informed consent from community-dwelling older individuals who met the inclusion and exclusion criteria. These individuals were recruited for the

study. Various outcome measures, including the Foot Posture Index (FPI), modified Four Square Step Test (mFSST), and Gait Speed Test (GST), were collected from these community-dwelling older individuals. The statistical data were analysed using Spearman's rank correlation in SPSS version 26.

## STATISTICAL ANALYSIS

The present study correlates foot posture (neutral, pronated, and supinated) with dynamic balance and gait speed in community-dwelling older individuals. Descriptive statistics and correlation analysis were performed using SPSS 26. The mean and standard deviation were calculated for each variable. The significance level was set at $P < 0.05$. Spearman's correlation coefficients(r) were used to determine the correlation of the different foot postures (neutral, pronated, and supinated) with dynamic balance and gait speed based on 0.00-0.10 = negligible correlation, 0.10-0.39 = weak correlation, 0.40-0.69 = moderate correlation, 0.70-0.89 = strong correlation, 0.90-1.00 = very strong correlation. [12]

## RESULT

**Table 1: Characteristics of the individuals ($N$ = 100) presents the demographic data, dynamic balance and gait speed in neutral, pronated and supinated feet.**

| CHARACTERISTICS | Normal (n =29) Mean ± SD | Pronated (n =36) Mean ± SD | Supinated (n = 33) Mean ± SD |
|---|---|---|---|
| Age (years) | 67.97 ± 4.52 | 70.25 ± 4.61 | 68.03 ± 6.25 |
| Gait Speed Test (m/sec) | 5.79 ± 0.77 | 18.67 ± 2.36 | 17.58 ± 2.16 |
| Modified four square step tests (sec) | 19.03 ± 3.79 | 46.22 ± 2.50 | 44.18 ± 3.46 |
| Foot Posture Index (Right) | 3.62 ± 1.01 | 7.53 ± 1.15 | -5.09 ± 1.37 |
| Foot Posture Index (Left) | 3.62 ± 1.01 | 7.53 ± 1.15 | -5.09 ± 1.37 |

Table 1 shows descriptive characteristics of individuals with the value of the mean and standard deviation of age, gait speed and dynamic balance in normal, pronated and supinated feet posture.

**Table 2: Spearman (r) correlation coefficients of gait speed and dynamic balance in normal feet, pronated feet and supinated feet**

| DIFFERENT TYPES OF FOOT POSTURE | | Gait Speed Test (m/Sec) | | Modified Four Square Step Test (Sec) | |
|---|---|---|---|---|---|
| | | correlation coefficients (r) | Level of significant ($p$) | correlation coefficients (r) | Level of significant ($p$) |
| Normal feet | Foot Posture Index (right foot) | 0.24 | 0.20 | 0.39 | 0.03 |
| | Foot Posture Index (left foot) | 0.24 | 0.20 | 0.39 | 0.03 |
| Pronated feet | Foot Posture Index (right foot) | 0.61 | 0.00 | 0.63 | 0.00 |
| | Foot Posture Index (left foot) | 0.61 | 0.00 | 0.63 | 0.00 |
| Supinated feet | Foot Posture Index (right foot) | -0.25 | 0.15 | -0.43 | 0.01 |
| | Foot Posture Index (left foot) | -0.25 | 0.15 | -0.43 | 0.01 |

Table 2 shows the correlations between gait speed, dynamic balance, and different foot postures in three groups: individuals with normal foot posture (n=29), pronated foot posture (n=36), and supinated foot posture (n=33). For those with normal foot posture, we found a weak positive correlation between gait speed and foot posture (rs = 0.24, P<0.05), as well as a statistically significant weak positive correlation between dynamic balance and foot posture (rs = 0.396, P< 0.05). Additionally, a moderate positive correlation was observed between gait speed and dynamic balance (rs

= 0.42, P< 0.05). In the pronated foot posture group, we identified a statistically significant moderate positive correlation between gait speed and foot posture (rs = 0.61, P<0.05), as well as a similar correlation between dynamic balance and foot posture (rs = 0.63, P< 0.05). Furthermore, a statistically significant moderate positive correlation was observed between gait speed and dynamic balance (rs = 0.59, P< 0.05). In contrast, for individuals with supinated foot posture, a weak negative correlation was found between gait speed and foot posture (rs = -0.25, P<0.05), while a statistically significant moderate negative correlation was noted between dynamic balance and foot posture (rs = -0.43, P< 0.05). Interestingly, there was a statistically significant moderate positive correlation between gait speed and dynamic balance (rs = 0.58, P< 0.05) in this group.

## DISCUSSION

Some studies have indicated that older adults are likelier to exhibit a pronated foot posture as they age. [13] Pronated foot posture refers to a condition where the arch of the foot collapses or flattens when standing, and the foot tends to roll inward. This observation is significant because it has implications for strategies to prevent falls and improve mobility in the elderly population. However, it's important to note that some conflicting research exists in this area. Some studies have suggested that the alignment of the feet, specifically whether they are pronated or not, may not significantly impact certain aspects of physical function, such as dynamic balance and gait speed. [14]

The current study provides evidence that older adults with a pronated foot posture may face greater challenges in dynamic balance and gait speed compared to those with supinated (where the foot rolls outward) or normal foot posture.

The reasons for these challenges in individuals with a pronated foot posture are multifaceted:

Altered Foot Pressure Distribution: Pronated feet often have a different pressure distribution across the sole. This altered pressure distribution can affect the stability of the foot, making it more challenging to maintain balance during dynamic movements.

Increased Plantar Pressure: Pronated feet can experience increased pressure on the foot's inner side, which can affect how the foot interacts with the ground. This increased pressure can compromise stability and contribute to difficulties in maintaining balance.

Reduced Muscle Activation Patterns: The muscle activation patterns in individuals with pronated feet may differ from those with other foot postures. This altered muscle activation can impact the ability to make quick adjustments in posture and balance, which is crucial for dynamic balance control. [15]

As a result of these factors, older adults with a pronated foot posture may experience decreased dynamic balance, meaning they could have more difficulty maintaining stability while moving, and they may exhibit slower gait speed compared to individuals with supinated or normal foot posture. [8] The present study is characterized by a limited number of participants included in the research was relatively small. The study collected data from a single geographic location or community. This can limit the external validity or generalizability of the findings. The characteristics of individuals in one area may not be representative of those in other areas, especially when it comes to factors like lifestyle, environmental conditions, and healthcare access. [16]

To address these limitations and expand our understanding of the relationship between different types of foot posture and dynamic balance and gait speed in older individuals, future research should be considered. This research could involve: larger sample size: conducting studies with a more extensive and diverse group of participants to increase the representativeness of the findings; multi-

location data collection: gathering data from multiple communities or regions to assess whether there are regional variations in the effects of different types of foot posture on dynamic balance and gait speed; intervention studies: implementing interventions to correct different types of foot posture and then examining their impact on balance and gait speed. this could help identify potential strategies for improving the mobility and stability of community-dwelling older individuals. By addressing these research avenues in future studies, we can enhance our understanding of the relationship between different types of foot posture and mobility in older individuals and develop more broadly applicable recommendations for improving their quality of life.

## CONCLUSION

The study results indicate that individuals with a pronated foot posture exhibit a more significant correlation with gait speed and dynamic balance when compared to those with a supinated or normal foot posture. These findings suggest that older adults with pronated foot posture may experience more pronounced effects on their gait speed and dynamic balance.

### *Declaration by Authors*

**Ethical Approval:** Approved

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**Conflict of Interest:** There no conflict of interest.

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