

Balance impairment, presence of fear of falling, and regional functional status in individuals with unilateral plantar fasciitis

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Abstract

Aim: Plantar fasciitis (PF) is a prevalent condition in which individuals usually adopt an antalgic gait pattern. These compensations change the joint position sense, cause body oscillations, and can impair balance. Limited information is available on the presence of balance impairment and its impact on fear of falling and foot function.

Materials and methods: This case control study enrolled 74 participants, 37 participants diagnosed with unilateral plantar fasciitis, with positive plantar stretch and windlass test, and 37 age-matched healthy subjects after obtaining written consent. The participants' balance, regional function, and fear of falling were measured using a balance and postural stability system, the Foot Function Index (FFI) and the Falls Efficacy Scale-I (FES-I) questionnaire. The influence of balance impairment on FES-I and FFI, as well as the cause-effect relationship, was analyzed using odds ratio and regression analysis.

Result: Postural sway in anteroposterior and mediolateral directions was compared between groups, and a significant difference was noted in the case group ($p < 0.0001$). The FES-I and FFI demonstrated greater fear of falling and decreased foot function in subjects with unilateral plantar fasciitis than the healthy controls ($p < 0.0001$). The odds ratio is 25.67, which reflects the causative relationship. Individuals with plantar fasciitis who had greater anteroposterior sway with eyes closed are at 1.9 times greater risk of being afraid of falling and 3.5 times greater risk of having reduction in foot function.

Conclusion: Individuals with plantar fasciitis had balance impairment with greater anteroposterior and lateral sway with eyes closed. Balance impairment influences fear of falling and regional foot function.

Keywords: Postural stability – Fall risk – Foot pain – Plantar fasciitis

Introduction

Plantar fasciitis (PF) is one of the most prevalent musculoskeletal disorders, characterized by pain at the origin of the plantar fascia, often involving surrounding perifascial structures (Tahririan et al., 2012). The hallmark symptom is medial heel pain, particularly noticeable during the first steps after rest or prolonged inactivity and often intensifying by the end of the day. While paraesthesia is rare, symptoms are typically unilateral, though up to 30% of cases present bilaterally. Achilles tendon stiffness is observed in nearly 80% of individuals with PF (Hossain & Makwana, 2011).

Recent literature emphasizes that PF is not merely an isolated inflammatory condition, but a multifactorial

degenerative disorder influenced by a complex interplay of biomechanical, anatomical, and systemic factors. Biomechanical dysfunctions such as limited ankle dorsiflexion, excessive foot pronation, poor hip stabilization, and altered gait mechanics are now recognized as key contributors to abnormal plantar fascia loading and microtrauma (Lee et al., 2021). The windlass mechanism, which governs the tensioning of the plantar fascia during toe-off, becomes compromised in individuals with flatfoot or restricted ankle mobility, leading to inefficient force transmission and increased fascial strain. Additionally, poor proximal control, particularly at the hip and pelvis, can alter lower limb alignment and exacerbate stress on the plantar fascia during dynamic activities.

The anatomical structure of the plantar fascia—composed primarily of type I collagen—makes it highly

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resistant to tensile forces but vulnerable to repetitive micro-tears under abnormal loading conditions. Over time, this leads to collagen degeneration, thickening of the fascia, and reduced elasticity, a process now referred to as plantar fasciosis rather than fasciitis, reflecting its non-inflammatory nature (Joshi & Rabra, 2025).

The etiology of PF is further complicated by demographic and psychosocial factors, including age, obesity, prolonged standing, and high-impact activities. Psychosocial stressors—such as pain catastrophizing, anxiety, and kinesiophobia—have been shown to amplify pain perception and contribute to chronicity (Gulle et al., 2024; Rhim et al., 2021). These factors not only influence symptom severity but also affect treatment outcomes and functional recovery.

Epidemiologically, PF accounts for approximately one million clinical visits annually and affects 10% of the general and athletic population. Among runners, prevalence may reach 22%, with 45.8% reporting acute morning heel pain. Severity varies, with 42.75% experiencing moderate pain and 13.74% reporting severe symptoms (McPoil et al., 2008). The condition is most common in adults aged 25–65, particularly those engaged in occupations requiring prolonged weight-bearing.

Functionally, PF leads to reduced walking speed, altered foot biomechanics, and diminished quality of life (Ambrose et al., 2013). Individuals often adopt an antalgic gait, minimizing heel contact and shifting weight to the lateral and forefoot regions. These compensatory strategies disrupt proprioceptive input and joint position sense, leading to postural instability and increased risk of falls (Dudoniene et al., 2022; Richer et al., 2022). Fascia thickening further impairs the foot's ability to absorb and redistribute forces, compounding balance deficits (Devika et al., 2020).

Balance and postural stability systems (BPSS) have emerged as sensitive and objective tools for assessing balance impairments in individuals with PF. Unlike traditional static or dynamic balance tests, BPSS provide real-time feedback and quantifiable metrics across multiple planes of motion (Paillard & Noé, 2015). This is particularly relevant given that PF has been linked to increased fall risk, even in individuals under 65 years of age (Chaiwanichsiri et al., 2008; Ağırman, 2018). Despite this, few studies have explored the direct relationship between unilateral heel pain, fear of falling, and regional functional limitations.

Studies reveal that plantar fasciitis increases the risk of falls in the elderly and among people younger than 65 years of age. Foot issues have been recognized as a fall risk factor; in particular, aching feet have been related to an increased likelihood of falling (Chaiwanichsiri et al., 2008). A previous study demonstrated that long-term lower body musculoskeletal discomfort had a detrimental effect on healthy adults' ability to balance (Ağırman, 2018). Falling is a significant public health issue that results in injuries. Plantar fasciitis negatively affects balance and

raises the risk of falls in the population under 65 years when compared to a healthy control. Testing fear of falling in younger adults is due to emerging evidence that it is not exclusive to the elderly and can significantly impact mobility, activity levels, and psychological well-being in younger populations—especially those with musculoskeletal conditions, neurological disorders, or a history of injury. Recent study also found that psychological factors such as kinesiophobia and fear of falling were significantly associated with foot pain severity and functional limitations—even in younger adults. It highlights the importance of assessing fear of falling as part of a comprehensive evaluation, regardless of age. (Gulle et al., 2024)

Limited information is available about the influence of balance impairment in patients with unilateral heel pain and whether it could be a causative factor for the fear of falling and functional limitation. This current study focuses on confirming the presence of balance impairment among individuals with unilateral plantar fasciitis and the influence of balance impairment on fear of falling and functional limitation.

This study aims to bridge that gap by evaluating balance impairment in individuals with unilateral PF and its association with fear of falling and functional status, thereby contributing to a more holistic understanding of the condition and informing targeted rehabilitation strategies.

Materials and methods

The present case-control research was authorized by the Institutional Ethical Committee (REF: CSP/23/SEP/136/810). The study has been registered with the Clinical Trials Registry – India (CTRI/2024/02/078958).

This research was started in March 2024 and completed in July of the same year. Using G*Power 3.0.1, the sample size is calculated, considering the expected effect size of 0.63 from earlier research with a level of significance of 0.05, a difference between two independent means, power of 0.80, and a 15% dropout rate. For this reason, 74 is the sample size.

The study was conducted in the outpatient section of the Faculty of Physiotherapy. The subjects are convenient samples recruited (in compliance with the Declaration of Helsinki and ethics committee approval) from the most accessible participants. Written informed consent was obtained from all participants prior to enrollment. Inclusion criteria include subjects diagnosed with unilateral plantar fasciitis of age from 25 to 65 years, both male and female, and of any body mass index (BMI). Exclusion criteria for the study were individuals with neurological problems interfering with balance, age more than 65 years, systematic inflammatory or autoimmune disease, foot disease, and medications taken that affect balance (for both case and control groups). Participants who had a positive response

with the plantar stretch and windlass test were included in the study. The enrolled study participants (14 men and 23 women in the case group and 12 men and 25 women in the control group) underwent a standard clinical examination including self-assessment and physical examination. Demographic data, including age, body height and weight, were collected for both groups (40.9 ± 8.9 years, 157.9 ± 4.59 cm, 70.1 kg and 40.9 ± 9.2 years, 156.8 ± 4.91 cm, 66.8 ± 9.24 kg for the case and control groups, respectively).

The baseline clinical data including pain intensity, ankle range of motion (ROM), posture stability, fear of falling and regional function were evaluated. These assessments were done using a BPSS, the Falls Efficacy Scale-I (FES-I), and the Foot Function Index (FFI). The pain intensity was measured using the Numerical Pain Rating Scale (NPRS) (Hartrick CT, 2003), and ankle range of motion (ROM) was measured using a goniometer for both the groups in supine lying and prone lying positions. In the BPSS, the center of foot pressure (CoFP) in the mediolateral direction (Xi) and anteroposterior direction (Yi) were measured under both eyes-open and eyes-closed conditions.

In subjects enrolled under the control group, demographic data, including age, gender, and BMI, were collected. Baseline data, including posture assessment with the BPSS and fear of falling, were measured using the Falls Efficacy Scale-I (FES-I) and the Foot Function Index.

Balance and postural stability system

A bioelectric BPSS was used in our study (Bio-Med International Pvt. Ltd., Model no: BMI-201). All subjects were examined by asking the participants to stand on the BPSS machine with shoes off. The anteroposterior and lateral sway are assessed for one trial each, and the values are noted. The measurements are taken for both case and control group to compare the presence of balance impairment in Plantar fasciitis individual and healthy subjects. The values of lateral sway (COFP Xi) and the Anteroposterior sway (COFP Yi) are measured in mm, and the corresponding graphs are obtained. The presence of COP in the grid close to 0 in the medial lateral axis represents lateral postural stability and close to 20 in the Anteroposterior axis reflects longitudinal stability. Individuals whose sway more than the above values are considered having greater postural sway considering these values as cutoff points for both anteroposterior and lateral directions.

Foot function index (FFI):

The Foot Function Index (FFI) is a tool used to assess how foot function affects pain, disability, and limitations on daily activities. It is a self-administered index with three

sub-scale and twenty-three items. Scores for overall and subscales are generated. Each question asks participants to rate how well their feet have been feeling during the last week (from bad to need support).

The nine items in the pain subcategory are used to quantify foot pain in different situations, such as walking barefoot versus wearing shoes. The disability subcategory has nine items that assess the degree of difficulty in doing various functional activities related to foot difficulties, such as climbing stairs. There are five items in the activity limitation subcategory, which measure activities that are limited due to foot difficulties, such as spending all day in bed. Higher ratings indicate worse pain. The visual analogue scale (VAS) is used to record the scores, which range from 0 to 10. Scores for each component in the subcategory and overall are computed. (Budiman-Mak *et al.*, 1991)

Falls Efficacy Scale International (FES-I)

The Falls Efficacy Scale International (FES-I) is a tool used to measure people's anxiety or fear of falling. A score of 16 indicates no fear about falling, whereas a score of 64 indicates severe anxiety about falling. This 16-item questionnaire is designed to assess fear of falls. Participants are asked to rate their level of fear of falling during an activity on a 4-point Likert scale, with 1 indicating no concern and 4 indicating extreme concern. The total is calculated by adding all the item scores—the higher the score, greater the presence of fear of falling (Dewan & MacDermid, 2014).

Participants were instructed to answer questions based on how often they perform the activity. For example, if a participant typically walks using a walking aid, they should respond to questions about walking by indicating their level of concern about falling while using that aid. Response options were provided on a scale, for example: 1 = not at all concerned, 2 = a little concerned, 3 = slightly concerned, 4 = extremely concerned. When translating the questionnaire into other languages, it is recommended to translate "opinion" as "statement" to maintain clarity.

The data collected from the BPSS, the Falls Efficacy Scale-I (FES-I), and the Foot Function Index were compared between the case and control groups to evaluate the presence of balance impairment, the presence of fear of falling, and regional functional status in individuals with plantar fasciitis compared to healthy individuals.

Ankle range of motion measurement

A standard universal goniometer was used to assess the range of motion (ROM) of the ankle joint. The participants are positioned comfortably in a seated position, with the knee flexed to about 90° , and the fulcrum of the goniometer is placed over the lateral malleolus for dorsiflexion and plantar flexion, with the stationary arm aligned along the

fibula pointing toward the fibular head, and the movable arm aligned parallel to the fifth metatarsal. For inversion and eversion, the subject is positioned sitting with the foot in neutral; the fulcrum is centered over the anterior aspect of the ankle between the malleoli, the stationary arm aligned along the midline of the lower leg, and the movable arm aligned with the second metatarsal. Measurements were taken by asking the participants to move their foot actively inward and outwards through its range.

Statistical method

The collected data were analyzed with IBM SPSS Statistics for Windows, Version 29.0 (Armonk, NY: IBM Corp). The data normality was assessed using the Shapiro-Wilks test, and the unpaired t test was used to compare the data between group and odds ratio was used to establish the case control effect. To determine the influence of balance impairment on fear of falling and foot function, the data collected from BPSS, FES-I, and FFI of the case group were analyzed through regression analysis. All *p*-values equal to or below 0.05 were considered statistically significant.

Results

The study recruited 74 participants who underwent all examinations. The baseline data are presented in Table 1.

Table 1. Baseline data for cases and controls

	Case group Mean $\pm$ SD	Control group Mean $\pm$ SD
BMI	28.6 $\pm$ 3.4	27.4 $\pm$ 4.1
Duration of pain (months)	2.5 $\pm$ 1.5	–
Pain intensity (NPRS)	7.2 $\pm$ 0.6	0
Ankle ROM – dorsiflexion (degrees)	12 $\pm$ 2.7	19 $\pm$ 1.2
Plantarflexion (degrees)	13 $\pm$ 2.7	30 $\pm$ 2.3
Inversion (degrees)	10.0	15
Eversion (degrees)	10.0	15

The difference in balance impairment, fear of falling, and regional foot function independent t-tests were used for the BPSS, the Falls Efficacy Scale-I (FES-I), and the Foot Function Index. The results are statistically significant (*p* < 0.001). (Table 2)

Table 2. Between-group data for balance, fear of falling and regional functional ability and their significance

Outcome measures		Case group Mean $\pm$ SD	Control group Mean $\pm$ SD	<i>p</i> -value
BPSS – lateral sway COFP Xi (mm)	Eyes open	1.99 $\pm$ 0.94	0.27 $\pm$ 0.70	< 0.0001
	Eyes closed	3.22 $\pm$ 1.14	1.14 $\pm$ 1.10	< 0.0001
BPSS – anteroposterior sway COFP Yi (mm)	Eyes open	22.43 $\pm$ 1.11	19.79 $\pm$ 0.94	< 0.0001
	Eyes closed	23.17 $\pm$ 1.07	20.06 $\pm$ 1	< 0.0001
Falls Efficacy Scale – International (FES – I)		54.97 $\pm$ 2.95	21.16 $\pm$ 1.32	< 0.0001
Foot Function Index (FFI)		62.2 $\pm$ 3.85	13.38 $\pm$ 4.23	< 0.0001

BPSS – balance and postural stability system. Unpaired t test.

Among 37 individuals with heel pain, 33 had significant postural sway, while 4 did not. Among 37 individuals without heel pain, 9 had significant postural sway, while 28 did not. The odds ratio was 25.67, indicating that individuals with heel pain had 25.67 times higher odds of exhibiting balance impairment compared to healthy controls (Table 3). Significant postural sway was defined as any value of the center of pressure (CoP) exceeding 0 in the mediolateral (X) axis and 20 in the anteroposterior

(Y) axis. Individuals whose CoP values exceeded these thresholds were considered to have greater postural sway, with these values serving as cut-off points for both directions.

Individuals with plantar fasciitis who had a greater anteroposterior sway have with eyes closed 1.9 times greater fear of falling. Individuals with plantar fasciitis who had a greater lateral sway with eyes closed have 3.5 times greater reduction in foot function. (Table 4)

Table 3. Presence of balance impairment in cases and controls and its associated odds ratio

Group	Presence of postural sway		Odds ratio
	(+)	(-)	
Case (<i>n</i> = 37)	33	4	25.67
Control (<i>n</i> = 37)	9	28	

Table 4. Influence of balance impairment on FES- I AND FFI (case group)

	<i>P</i> value	Beta value	R square
COFP Yi eyes closed (FES – I)	< 0.001	1.18	55%
COFP Xi eyes closed (FFI)	< 0.007	1.12	55%

COFP Yi – anteroposterior sway, COFP Xi – lateral sway, FES-I – Falls Efficacy Scale-International, FFI – Foot Function Index. Multiple regression analysis using backward elimination method.

Discussion

Plantar fasciitis is one of the most prevalent health disorders of the foot, and the findings of the current study confirm the presence of balance impairment when compared to age-matched healthy persons. In individuals with unilateral heel pain, the presence of greater postural sway influences fear of falling and their regional function. In the current study, the balance impairment was measured using the BPSS, where subjects with plantar fasciitis had greater postural sway in both anteroposterior (AP) and lateral directions. (Table 2)

In the current study, more females were enrolled (male – 26, female – 48), whereas previous studies had included more male individuals. The age range was 25–62 years in the current study, compared to 18–60, 30–50, and 20–60 years in similar studies (Akinoğlu *et al.*, 2017). Analysis of age-wise data indicated that balance impairment was present across all age groups in the heel pain population. Age did not appear to influence balance impairment, suggesting that it was primarily attributable to plantar fasciitis. Previous studies with similar objectives have also reported balance impairment, particularly in the mediolateral direction, with assessments conducted using the Biodex Balance System or the Foot Posture Index.

The present study confirmed the presence of balance impairment using BPSS, and the influence of age and gender was not analyzed. The same information was not available in previous literature, and future studies can address this gap. In the current study, out of 74 subjects,

only 6 individuals had diabetes mellitus, and whether it could influence balance was unknown. No sensory or proprioception evaluation was conducted; it would have enabled comparison of deficits between diabetic and non-diabetic individuals.

In this study, the number of individuals with 4, 8, and 12-week duration of pain was 18, 10, and 9, respectively. The mean lateral and anterior posterior sway for the above duration was 2.89, 12.36; 3.09, 12.65; and 3.33, 13.03, respectively. As the duration increased, the sway also increased. Hence, symptom duration could influence the balance impairment, and chronicity of the symptom could precipitate the problem.

Individuals with plantar fasciitis often exhibit an antalgic gait, where they place additional support on the anterior and lateral sides of their feet to reduce heel contact time with the ground. Compensations change proprioception, causing oscillations in the body that can impair balance and make maintaining an upright posture difficult (Chang *et al.*, 2014). Therefore, correlating balance impairment and proprioceptive deficit in the same population and analyzing the influence of one over the other would be of great clinical value. The presence of fear of falling was evaluated correlating balance response obtained through the Biodex system in a dichotomized way. In the current research, the FES I questionnaire was used to evaluate the presence of fear of falling.

As identified by King *et al.* (2019), reduced plantar fascia elasticity during daily activities might worsen balance and cause more muscle tremors. This reduction in elasticity would cause a delay in the passage of energy, like a weakening spring, and would lengthen the ankle's range of motion, resulting in impaired balance. The above phenomenon could be the reason for increased postural sway in these individuals, as observed in the current study, placing them in a state of increased fear of falling.

Our study proves that individuals with heel pain are vulnerable to acquiring balance problems, and they have 25.6 times greater risk of having balance impairment when compared to age-matched controls. (Table 3) Increased BMI leads to increased thickness of plantar fascia (Hamstra-Wright *et al.*, 2021), and its correlation with postural sway reflects the role of both in precipitating balance impairment among individuals with plantar fasciitis.

Individuals with heel pain have greater fear of falling than healthy individuals. In healthy individuals, fear of falling was not present in the age range of 25–35 years, and very mild fear of falling was present in the age range of 36–65. In individuals with heel pain, a moderate to severe fear of falling was found in the age range of 25–35 years, and a severe fear of falling was found in the age range of 36–65. This clearly indicates that the presence of balance impairment in individuals with heel pain is the cause of this fear factor.

Other research was conducted with subjects in a chronic stage of the condition, who had a severe reduction in foot function (Budiman-Mak *et al.*, 1991). In contrast, in the current study the subjects recruited were in the subacute

stage of the condition and had a moderate to severe reduction in foot function. The Foot Function Index revealed minimally significant variations in pain (12), disability (7), and total foot function (7). In this study, the minimum difference of the Foot Function Index was found to be 20 for pain, 16 for disability, and 20 for total value in subjects with plantar fasciitis.

The impact of balance impairment on fear of falling and foot function in people with unilateral plantar fasciitis is well established in the current study. This is in line with a study which confirmed a significant association between kinesiophobia and catastrophizing with foot function (Cotchett et al., 2007). Subjects with heel pain who exhibited a larger anterior sway with their eyes closed had an increased fear of falling. The loss of foot function is larger in those with heel pain who had more lateral sway with their eyes closed. (Table 4)

Limitations and recommendations

This research established the existence of balance impairment using the BPSS in individuals with unilateral plantar fasciitis, but the impact of gender and age was not addressed.

This study did not analyze balance evaluation in individuals with plantar fasciitis correlating the gait, proprioception, and other functions using a functional outcome measure; this could be explored in future studies.

Conclusion

Individuals with plantar fasciitis had balance impairment with greater anteroposterior and lateral sway with the eyes closed compared to healthy individuals. Individuals with heel pain and balance impairment may have greater fear of falling and a regional functional deficit. These findings suggest that balance impairment influences the fear of falling and foot function in individuals with unilateral plantar fasciitis.

Conflict of interest: Author state no conflict of interest

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