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Prevalence of Impaired Joint Position Sense in Patients with Plantar Fasciitis: A Cross-Sectional Study

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ABSTRACT

Background: The plantar fasciitis is a degenerative condition involving recurrent microtears and compromised biomechanics. It affects the Pacini and Ruffini corpuscles, which play a crucial role in proprioception. Compensation methods prompted by pain and alterations in biomechanics may compromise the joint position sense of the ankle joint. The study aims to determine the prevalence of impaired joint position sense in plantar fasciitis patients using smartphone apps.

Methods: The study included 43 patients aged 20-50 years, encompassing both genders, with 28 females and 15 males. Patients with knee and ankle pathologies were not included in the study. The ankle joint position sense of the patients was measured using a smartphone application called Sensor Kinetics Pro 2.1.2, which provided angular velocities in three planes (X, Y, Z). The statistical analysis was carried out using SPSS 20.0, where a p-value of < 0.05 is considered statistically significant.

Results: Of 43 patients with plantar fasciitis, the prevalence percentage of impaired joint position was 32.6%. Further, the joint position sense, as found in the application, was affected in the three planes (X, Y, Z) with a prevalence of 27.9%, 32.6%, and 39.5%, respectively.

Conclusion: The present study concludes that joint position sense affects patients with plantar fasciitis; however, further studies should be conducted to generalize the results.

Keywords: heel pain, proprioception, smartphone app, mechanoreceptors, gyroscope.

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INTRODUCTION

Plantar fascia is a connective tissue band extending from the calcaneus, or heel bone, to the forefoot. This structure supports the foot arch while acting as a shock absorber during various activities. It is strongly related to the superficial muscular tissues, especially to the proximal insertions [1]. Plantar fasciitis is a condition affecting the plantar fascia that causes tension and degeneration due to biomechanical imbalance. It is generally triggered by microtears inside the heel and characterized by pain that worsens with weight-bearing, exacerbated by weight problems, flat feet, decreased ankle dorsiflexion, and heel spurs [2,3]. Plantar fasciitis is anticipated to impact approximately 10% of the population at some point in their lives. Additionally, it accounts for 11-15% of adult foot complaints that require professional treatment [4,5]. The dynamic stabilizer muscle tissues surrounding the ankle joint may also play a vital function in plantar fasciitis [6]. According to research, the plantar fascia is incredibly innervated, especially where the sole muscle mass is inserted and in which it links to the fasciae of the abductor hallucis and the abductor digiti minimi muscle [7]. Sherrington coined proprioception in the early 1900s to explain collective neural input to the Nervous System from the mechanoreceptors inside joint capsules, ligaments, muscles, tendons, and skin, detecting stimuli like pain, pressure, touch, and motion [8,9]. Pacini-Ruffini cells are commonly thought to be responsible for mechanoreception [10]. Proprioception, particularly ankle proprioception, is crucial for maintaining balance and regulating muscles during functional activities like standing, moving, and sprinting, relying on afferent impulses from multiple receptors [7]. Proprioception comprises kinesthesia, which pertains to the awareness of joint movement, and joint position sense (JPS), which involves identifying static joint position [11]. JPS is essential for joint stability, originating from various brain sources and regulated by receptors and afferent routes. Proprioception, including JPS, kinesthesia, and force sense, is essential for motor control, with joint position sense tasks as a reliable assessment tool [12,7]. The wearable sensors and smartphones are valuable tools with great potential for assessing joint excursions using built-in accelerometers, magnetometers, and gyroscopic sensors. These devices have been validated for evaluating JPS and auto-sensory subgenres [6]. Smartphones can measure static joints accurately, potentially replacing more expensive, traditional methods. The accuracy of the JPS measurements of ankle dorsiflexion–plantar flexion made with cellphones was more significant than 0.74 [11,12]. Intact JPS is a clinically important concept for preserving joint elasticity.[12] However, no literature focuses on JPS in patients with plantar fasciitis. Thus, the study aims to determine the prevalence of JPS in patients with plantar fasciitis. This can guide clinicians and physiotherapists in delivering a comprehensive treatment to patients with plantar fasciitis.

METHODS

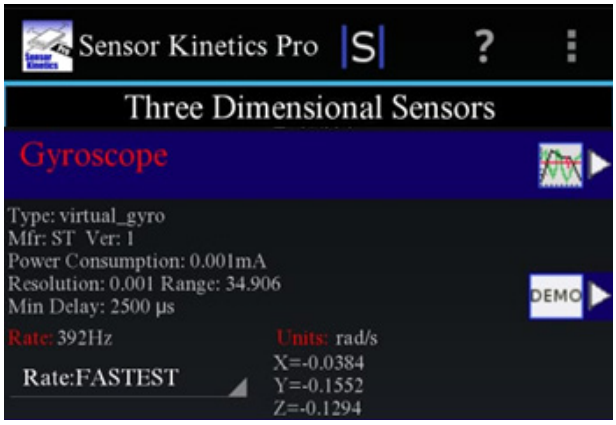
Study participants

A cross-sectional study involved plantar fasciitis patients aged 20 to 50 years diagnosed and referred by an orthopedician to the physiotherapy outpatient department of a tertiary care hospital in Mangaluru, Karnataka, India. The patients were screened for pain using Numerical Pain Rating Scale (NPRS) scores ranging from 0-6. Patients with knee pathology and ankle conditions such as sprain, fractures, and deformities and those with a body mass index (BMI) of more than 30 kg/m^2 were excluded. The study used a convenient sampling procedure, with a sample size of 43, which was determined based on an 11% prevalence rate for plantar fasciitis [4,5].

Study procedure

The patients included in the study were assessed for JPS using the gyroscope of Sensor Kinetics Pro-2.1.2, a smartphone application running on a Redmi 10 Prime 2022 smartphone. The validity and reliability of ankle dorsi-plantar flexion measurement using smartphones were high, with good ICC values (0.79 and 0.74, respectively) [12]. (figure 1)

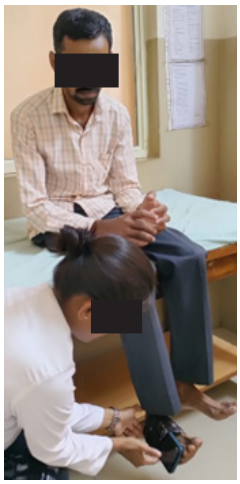
Figure 1: Screenshot of the Readings of Smartphone Application



The patients were positioned on a height chair with their feet not touching the floor, and a smartphone was attached to their lateral ankle using Velcro. While seated, a therapist guided the patients to perform ankle dorsiflexion and plantarflexion, as shown in Figure 2, 3. They were asked to manually set an angle, remember it, and reproduce it without speaking during the measurement. The patient's JPS was measured three times in each of the three planes (X, Y, Z), and the results were combined to calculate an overall average, with the examiner providing necessary verbal instructions. This study has been formally approved by the University Institutional Ethics Committee (Ref: NIPT/IEC/Min/25/2022-2023) and was registered in the Clinical Trial Registry-India (CTRI/2023/04/052051). Informed consent has been acquired from every patient participating in this study.

Figure 2: Joint Position Sense (Dorsiflexion) Assessment of Patient with Smartphone Application

Figure 3: Joint Position Sense (Plantarflexion) Assessment of Patient with Smartphone Application



Data Analysis

The data we collected were analyzed using statistical methods, including frequency and percentage distributions. We performed the statistical analysis with SPSS version 20.0 (Statistical Package for the Social Sciences). Categorical variables were presented as frequencies and percentages to determine the prevalence of JPS in cases of plantar fasciitis, while continuous variables were reported as mean ± standard deviation. Results are presented as absolute number (N) and percentage (%) of responses or median (interquartile range) and range (min-max) for continuous variables. We also conducted a secondary analysis using one-way ANOVA and a post hoc Tukey test to explore the relationship between BMI and the angular velocities of X, Y, and Z planes. Statistical significance was determined using a p-value of less than 0.05 for all analyses.

RESULTS

In the study, 88 patients were screened, and 43 were included, consisting of 15 males and 28 females aged between 20 and 50 years, with a mean ± SD of 33.6 ± 11.3. Detailed demographic characteristics, including age and BMI, are in Table 1. BMI distribution was 5% underweight, 60% normal weight, and 35% pre-obese (overweight).

Table 1: Descriptive statistics for age and BMI

Demographic variableS	N	Mean ± SD	Median (IQR)	Range (min-max)
AGE (years)	43	33.6 ± 11.3	35(23,45)	19 - 50
BMI (kg/m^2)	43	23.65 ± 3.48	23.3(21.2,25.9)	18 - 32

(SD- standard deviation, N- frequency, IQR- interquartile range)

Joint position sense (JPS) is recorded using gyroscopic components in the application represented in the X, Y, and Z planes. In Table 2, the study presents the mean, median, and range (min-max) of angular velocities measured with a gyroscope in three planes (X, Y, and Z) for 43 patients in each plane. The data shows that the mean±SD for angular velocity across all planes was 0.05±0.1 rads/second. The prevalence of impaired JPS across each plane is represented as frequency and percentage in Tables 3 and 4. Fourteen patients exhibited impaired JPS, while 29 patients had no impaired JPS.

Table 2: Table showing mean±SD, median, range of angular velocities in a different plane

Angular Velocity in different planes (rads/secs)	N	Mean ± SD	Median (IQR)	Range (min-max)
X- plane	43	0.06 ± 0.17	0.06(-0.01,0.18)	-0.34 - 0.42
Y- plane	43	0.04 ± 0.13	0.04(-0.07,0.12)	-0.23 - 0.46
Z- plane	43	0.04 ± 0.22	0.03(-0.1,0.19)	-0.49 - 0.38
Angular velocities in X, Y, Z	43	0.05 ± 0.1	0.02(-0.01,0.08)	-0.12 - 0.4

(rad/secs: radians/ second, SD- standard deviation, N- frequency, IQR- interquartile range)

Table 3: Table showing percentages of JPS impairment in X, Y, and Z planes, calculated by frequency and percentage for the categorical variables.

JPS	X	Percentage	Y	Percentage	Z	Percentage
Not impaired	31	72.1%	29	67.4%	26	60.5%
Impaired	12	27.9%	14	32.6%	17	39.5%
Total	43	100%	43	100%	43	100%

(JPS: joint position sense)

Table 4: Table displaying the average percentages of JPS impairment, calculated using frequency and percentage for categorical variables X, Y, and Z planes.

JPS	N	Prevalence %
Not Impaired	29	67.4%
Impaired	14	32.6%
Total	43	100%

(JPS: joint position sense, N: total number of patients)

A secondary analysis was also done to determine whether BMI affects the JPS. The angular velocities in three planes, X, Y, and Z, were compared with BMI categories using one-way ANOVA and a post hoc Tukey test. No significant differences ($p>0.05$) were seen between angular velocities and different categories of BMI. Pre-obese individuals had a high mean angular velocity as compared to the underweight and normal BMI categories. However, no significant differences were observed between the three categories ($p>0.05$) as shown in the Table 5.

Table 5: Showing the comparison of Angular velocities in X, Y, and Z planes and with three categories of BMI using ANOVA

Angular velocities of PlaneS	BMI (kg/m²)			p value
	Underweight (<18.5 kg/m²) (N=2) Mean ± SD	Normal weight (18.5-24.9) (N=26) Mean ± SD	PreObesity (overweight) (25-29.9) (N=15) Mean ± SD	
X	0.23 ± 0.02	0.05 ± 0.19	0.07 ± 0.13	0.357
Y	0.05 ± 0.05	0.04 ± 0.15	0.04 ± 0.11	0.997
Z	-0.25 ± 0.09	0.05 ± 0.22	0.05 ± 0.2	0.177
AVERAGE of X, Y, Z	0.01 ± 0.02	0.05 ± 0.1	0.05 ± 0.09	0.84

(SD- standard deviation, N- frequency, p-value < 0.05)

DISCUSSION

Plantar fasciitis causes pain in the heel and affects balance and mobility [3]. Various methods for measuring proprioception include JPS, kinesthesia, and force sense. Advancements in technology, such as affordable gyroscope sensors in smartphones, have made assessing proprioception abilities more accessible [7, 13]. A study by Lee D, 2017 [12] showed the high validity and reliability of smartphone applications in JPS of ankle joint movement compared to electro goniometer; the reliability JPS measurement of ankle dorsiflexion and plantarflexion was higher than 0.74 obtained by smartphone, which implies that the smartphones offer high validity and reliability as a tool for measuring JPS of dorsiflexion and plantarflexion of the ankle. Similarly, Seul Ki Han, 2022 [13] conducted a study to evaluate the reliability of measuring the position sense of knee and ankle joints using a smartphone application akin to the one employed in the present study across individuals of varying ages. The study's results confirmed that position sense can be reliably assessed through the smartphone application, as evidenced by its high reliability.

The current study used a smartphone application, Sensor Kinematics Pro-2.1.2, to investigate the prevalence of impaired JPS in plantar fasciitis patients.

The present study analyzed the angular velocities of the ankle joint in three planes: X, Y, and Z. The findings of the study state that 32.6% of the 43 patients reported a decrease in their perception of JPS when assessed by a smartphone application. The findings demonstrate impairments of 27.9% in the X plane, 32.6% in the Y plane, and 39.5% in the Z plane. These findings suggest that patients with plantar fasciitis may have impaired proprioception across the axes of motion in the foot and ankle complexes. According to the present study, Z-plane deficits, including dorsiflexion and plantarflexion motions, were more common among the patients.

Literature supports proprioceptive information regarding the position and movement of the ankle, which play a crucial role in the neural regulation of gait and balance. A recent study by Fareed F Alfaya, 2023 [14] investigated ankle JPS and balance through computerized posturography in individuals with chronic ankle instability. The results indicated that the individuals with chronic ankle instability exhibit impaired ankle JPS, and this deficit significantly correlates with a decrease in balance. In a study, Ahmad H. Alghadir, 2022 [15] examined athletes with ankle sprains to assess how chronic ankle sprains impact pain, range of motion, proprioception, and balance. The findings indicated that patients with chronic ankle sprains exhibited ankle proprioception and balance deficiencies. This suggests that these deficiencies contribute to limitations in the ankle joint's dynamic defense system, potentially making individuals more susceptible to recurring injuries and instability. We also found impaired JPS; however, the population in the present study has plantar fasciitis.

In a secondary analysis, the BMI in the present study was compared with angular velocities in three planes (X, Y, Z), and no significant difference was observed. Though a higher angular mean velocity in the Z plane was demonstrated in the patients with higher BMI, there were no statistically significant differences. In contrast with our study, Min-Hyeok Kang and colleagues, 2022 [16] compared foot posture, joint position sense, balance, and plantar pressure among overweight and lean younger adults. They found position perception errors in a significantly higher range of motion for the obese group (p: 0.017), indicating that this group might perform torsion motions.

Furthermore, this study used gyroscope sensors in the Sensor Kinetics Pro 2.1.2 implementation, which showed strong reliability and validity for quantifying proprioceptive perception when a sample of 43 patients with plantar fasciitis was studied, and the results showed patients with plantar fasciitis have a prevalence of impaired joint position sense. Further research may be needed to validate the results.

CONCLUSION

The study underscores the significance of evaluating joint position sense in individuals diagnosed with plantar fasciitis. Notably, it elucidates that proprioceptive impairment is manifested by a diminished joint position sense in plantar fasciitis patients. These findings offer insights for assessing and managing joint position sense in patients with plantar fasciitis.

ABBREVIATION

X, Y, Z- Angular velocities in three-planes
JPS- Joint position sense
BMI- Body mass index
NPRS- Numerical pain rating scale
ICC- Interclass correlation coefficient
SPSS- Statistical packages for social sciences
SD- Standard deviation

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of this research.

CONFLICT OF INTEREST

The authors hereby declare that there are no conflicts of interest to disclose.

ETHICAL APPROVAL

This study received approval from the Institutional Ethics Committee of the University (Ref: NIPT/IEC/Min/25/2022-2023)

INFORMED CONSENT

All participants provided their written informed consent before the commencement of the study.

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