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Association between Foot Posture Asymmetry, Dynamic Stability, and Disability in Gujarati Adults with Primary Osteoarthritis of the Knee

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Abstract

Background: Knee osteoarthritis (KOA) is a prevalent degenerative disease that significantly impairs daily functioning owing to joint instability, pain, and stiffness. Foot posture asymmetry and dynamic stability could play a role in functional disability in individuals with KOA, yet limited research has examined this relationship.

Objectives: This study investigated the associations between foot posture asymmetry, dynamic stability, and disability in the Gujarati adult population with KOA compared with healthy controls.

Methods and Materials: An observational study was conducted with 40 participants (20 patients with KOA and 20 healthy controls). Foot posture asymmetry was assessed using the Foot Posture Index (FPI), dynamic stability was measured with the Sense Balance MiniBoard (Sensamove, Netherlands), and functional disability was evaluated using the modified Western Ontario and McMaster Universities Osteoarthritis Index (mWOMAC). Non-parametric tests were used for group comparisons, and Spearman's rho was used to determine correlations.

Results: Patients with KOA demonstrated significantly higher FPI scores, indicating more pronated feet (mean FPI: right 6.2, left 5.8) than controls (right 2.35, left 2.2). Dynamic stability was also impaired in KOA patients, with lower mediolateral (50.25%) and anteroposterior (62.45%) stability than in controls. A positive correlation was found between foot posture asymmetry and disability ($r = 0.51$; $p = 0.02$). KOA severity correlated moderately with foot posture asymmetry ($r = 0.656$, $p < 0.01$) and strongly with disability ($r = 0.80$, $p < 0.01$).

Conclusion: This study found a very weak to moderate association between foot posture asymmetry, dynamic stability, and disability in the Gujarati adult population with KOA.

Keywords: Knee osteoarthritis; Foot posture asymmetry; Dynamic stability; Disability; FPI; mWOMAC; The Sense Balance Miniboard.

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INTRODUCTION

Knee osteoarthritis (KOA) is a progressive joint disease characterized by cartilage deterioration, bone remodeling, and inflammation, resulting in pain and reduced mobility. Affecting nearly 10% of individuals over 45 years of age and a substantial percentage of the elderly population worldwide, KOA poses a significant public health burden, with pain and instability impeding daily activities and work productivity.[1,2] The alignment and stability of the knee are biomechanically influenced by foot posture and stability, essential for weight distribution and movement control. Previous studies have indicated that KOA patients frequently exhibit pronated foot posture, which affects knee joint alignment, exacerbates pain, and reduces stability. Dynamic stability, or the ability to maintain balance during movement, is also compromised in KOA due to muscle weakness and impaired proprioception.[3] Although evidence supports a relationship between foot posture, dynamic stability, and knee osteoarthritis, few studies have specifically examined this association in the Gujarati population in India.[4-9]

This study aimed to: (a) assess foot posture asymmetry, dynamic stability, and disability in primary KOA patients compared to controls; (b) determine whether foot posture correlates with KOA severity based on the Kellgren-Lawrence (KL) grading scale; and (c) explore the associations between foot posture, dynamic stability, and disability.

METHODS AND MATERIALS

Participants

The Institutional Ethics Committee of the Sarvajanik College of Physiotherapy, Surat, approved this observational study. Forty individuals (20 patients with KOA and 20 healthy controls) aged 50-70 years were recruited using convenience sampling. The KOA diagnosis was confirmed using the KL grading scale, and all KOA participants had grades of at least 1 in one or both knees. **Inclusion Criteria for KOA Patients: (a)** diagnosed with primary KOA by an orthopedic surgeon or physician; (b) aged between 50 and 70 years; (c) KL grade ≥ 1 in one or both knees; and (d) ability to stand independently on the Sensamove platform for 60 seconds without assistive devices. **The inclusion criteria for Healthy Subjects were as follows: (a)** age between 50 and 70 years; (b) no history of neurological, spinal, or ankle diseases, lower extremity trauma, surgery, or deformity. **The exclusion criteria for KOA Patients were as follows:** (a) inflammatory rheumatic diseases or arthritis; (b) neurological disorders (e.g., stroke, Parkinson's disease); (c) congenital or traumatic lower limb deformity; and (d) history of ankle diseases, fractures, or surgery. The calculated sample size was 20 participants per group. This sample size was based on data provided by Gosavi *et al.*[10], calculated using WinPepi Software for Windows. The sample size was calculated using the following inputs: type I error of 0.05, power of 0.80, and mean difference of 2.4.

Outcome measures

Foot Posture Index (FPI-6): A clinical assessment tool to categorize foot posture as pronated, neutral, or supinated based on six criteria, including talar head palpation and calcaneal angle.[11]

Sense Balance Mini Board: A balance testing tool that measures stability in the mediolateral (M-L) and anteroposterior (A-P) directions.

Fig. 1: Sensamove® Equipment

- Modified Western Ontario and McMaster Universities Osteoarthritis Index (mWOMAC): A validated, self-administered questionnaire adapted for the Gujarati population, assessing pain, stiffness, and functional disability.[12,13]

Procedure

After informed consent was obtained, the FPI-6 and dynamic stability tests were performed for each participant. Patients with KOA completed the mWOMAC survey, and the FPI and dynamic stability scores were recorded for analysis.

Each participant performed balance tests in two 60-second trials on the SenseBalanceMiniBoard with a 2-minute rest period between trials. The FPI-6 was used to evaluate foot posture on both feet. The FPI-6 consists of six items, including talar head palpation, curves above and below the lateral malleoli, calcaneal angle, talonavicular bulge, medial longitudinal arch, and forefoot to rearfoot alignment; each item is scored between -2 and +2. According to the total sum of all items, the feet were categorized into three groups: neutral ($0 \leq FPI \leq 5$), pronated ($5 < FPI \leq 12$), and supinated ($-12 \leq FPI < 0$). The participants were asked to march on the spot, settle into a relaxed and comfortable position, stand barefoot on both legs with their arms by the side, and look straight ahead. The participants were required to not swivel during the assessment to avoid affecting their foot posture. All the participants were evaluated on both feet.[11]

A SenseBalance Mini Board (Sensamove, Netherlands) was used to determine the dynamic stability of patients. The subject stood on a SenseBalance Mini board, which was set on the smallest hemisphere (rubber accessory-15-degree tilt). We tested the dynamic stability of the bilateral stance (Ankle, Knee & Hip are involved in maintaining a balance of bilateral stance on the Balance Board). In this test, the subject was instructed to stand on both legs for 60 seconds. They stood barefooted with their hands placed on their hips (akimbo) and looked at a mark placed at eye height on the wall 1.5 meters away. The participants were allowed one trial before recording to familiarize themselves with the task. Marks on the wobble board at the midline and back of the heel were used to standardize foot position. The testing was performed twice; in each trial, the participants had 3 seconds to find their balance before the recording began. There was no distracting noise or conversation during the testing. No attempts were made to blind the participants or tester. There was a pause of at least 2 min between the trials.[14]

The mWOMAC is a self-reported ultidimensional instrument used to assess symptoms and function in individuals with hip or knee osteoarthritis (OA). It consists of 24 items that are divided into three domains. Five questions assessed pain, two assessed stiffness, and 17 assessed functional activities. The test questions are scored on a scale of 0-4, which correspond to: **(a)** none – 0; **(b)** mild – 1; **(c)** moderate – 2; **(d)** severe – 3; and **(e)** extreme – 4.

The mWOMAC Gujarati version of the questionnaire was internally consistent with a high Cronbach's alpha score of 0.936 (test) and 0.940 (retest). Test-retest reliability was analyzed using the mixed-model intraclass correlation coefficient (ICC) and was found to be satisfactory, with an ICC of 0.986. The mWOMAC Gujarati version is a reliable and valid[12] self-rated clinical instrument for assessing the symptoms and function of knees with OA.[13]

Statistical Analysis

Continuous variables were analyzed for normality using the Shapiro-Wilk test. The Mann-Whitney U test was used to compare means between groups, and Spearman's rho was used to determine correlations between variables. Statistical significance was set at $p < 0.05$.

RESULTS

years, KOA patients had a mean age of 59.5 ± 7.4 years, while the control group was 54.6 ± 5.3 years. The KOA group consisted of three males and 17 females, while the control group included nine males and 11 females.

Foot Posture Index (FPI)

KOA patients exhibited significantly higher FPI scores than controls ($p < 0.001$), indicating a more pronated foot posture. The right-foot FPI in the KOA group was 6.2 ± 2.3, and the left-foot FPI was 5.8 ± 3.2, showing a mild asymmetry not seen in the control group.

Table 1: Comparison of mean of FPI between PG and CG

	PG Mean±SD	CG Mean±SD	Mean difference (CI: lower-upper)	Effect Size
FPI Right	6.2±2.3	2.35±2.3	3.85(2.34 – 5.35)	1.6
FPI Left	5.8000±3.2	2.2±2.3	3.6 (1.79 – 5.40)	1.3

PG: Patient Group; CG: Control Group

Dynamic Stability

Dynamic stability was significantly lower in patients with KOA. The mean M-L stability of KOA patients was 50.25%, and the A-P stability was 62.45%, compared to controls at 56% (M-L) and 75.5% (A-P), indicating impaired dynamic balance ($p < 0.01$).

Associations between FPI, Sensamove performance, and mWOMAC

Moderate correlations were found between FPI and mWOMAC scores in KOA patients, suggesting that a more pronated foot posture is related to increased disability. No significant correlation was observed between the FPI and SenseBalance Performance in the control group.

Table 2: Comparison of the mean of sensamove performance between PG and CG

Group		Mean	Std. Deviation
PG	M-L(%)	50.25	9.49
	A-P(%)	62.45	15.29
CG	M-L(%)	56.00	10.31
	A-P(%)	75.50	10.30

Table 3: Correlation between FPI, sensamove performance, and mWOMAC

Group			M-L (%)	A-P (%)	mWOMAC
PG	mWOMAC	Correlation Coefficient	0.01	0.02	NA
		Sig.(2-tailed)	0.96	0.90	.NA
	FPI Right	Correlation Coefficient	-0.07	0.11	0.18
		Sig.(2-tailed)	0.75	0.63	0.44
	FPI Left	Correlation Coefficient	0.05	-0.02	0.51*
		Sig. (2-tailed)	0.80	0.92	0.02
CG	mWOMAC	Correlation Coefficient	NA	NA	NA
		Sig.(2-tailed)	NA	NA	NA
	FPI Right	Correlation Coefficient	0.25	0.10	NA
		Sig. (2-tailed)	0.27	0.64	NA
	FPI Left	Correlation Coefficient	0.03	-0.10	NA
		Sig. (2-tailed)	0.88	0.67	NA

N/A: Not applicable. *significance P<0.05

DISCUSSION

KOA and Dynamic Stability

This study highlights that foot posture asymmetry and compromised dynamic stability contribute to functional disability in patients with KOA. Our findings align with prior research showing that a pronated foot posture increases joint stress and can alter knee alignment, potentially worsening KOA symptoms. Specifically, higher FPI scores among patients with KOA reflect a pronated stance, which has been associated with medial knee joint loading and further degenerative changes.

Supporting our findings, Kim *et al.*[15] explored the relationship between pain, quadriceps strength, proprioception, and dynamic balance in women with knee osteoarthritis. Their study highlighted that KOA pain is associated with reduced quadriceps strength, impaired proprioception, and decreased dynamic balance. This reduction in dynamic balance may be attributed to muscle weakness and reduced physical activity, both of which contribute to a functional decline. Additionally, pain in KOA can impair proprioception, complicating balance and movement control, thereby increasing the risk of falls in this population.

Similarly, Mahmoudian *et al.*[16] found that older adults with knee osteoarthritis demonstrated lower time-averaged knee local stability in their unaffected leg than their healthy counterparts. This reduced stability was observed even in legs without osteoarthritis, underscoring the systemic impact of KOA on balance and stability.

Furthermore, Raizah *et al.*[17] reported that individuals with KOA show impairments in knee proprioception and limits of stability compared with

asymptomatic individuals. These proprioceptive deficits likely affect balance, making dynamic stability assessments crucial for identifying at-risk populations.

In another relevant study, Laessoe *et al.*[14] used an instrumented wobble board to assess functional ankle instability in young adults with a history of ankle sprains. They found that individuals with ankle instability exhibited significantly greater M-L tilt variations during a 20-second one-leg stance test than the control group. This result demonstrates the effectiveness of using instrumented stability boards to assess functional instability, supporting the methodology used in the current study to evaluate KOA-related stability deficits.

KOA and Foot Posture

This study observed that a significant number of individuals with knee osteoarthritis (KOA) had Kellgren-Lawrence (KL) grades of 2 or 3, with a moderate positive correlation (r = 0.65) between KL grade and Foot Posture Index (FPI) scores. This correlation suggests that foot posture asymmetry increases with KOA severity, as indicated by the KL grading.

The importance of assessing foot and ankle alignment in lower-limb osteoarthritis (OA) has been highlighted in previous research by Reilly *et al.*[18] Reilly and colleagues argued that foot and ankle alignment has a considerable impact on the distribution of forces through the lower limb, which can influence the development and progression of OA. The authors cite growing evidence that supports including foot and ankle assessments in OA management, as individuals with knee OA are more prone to pronated foot posture, potentially contributing to additional stress on the affected joints.

In this study, a comparison of FPI scores between the patient group (PG) and the control group (CG) demonstrated that PG participants had higher FPI scores, indicating greater foot pronation than the controls. Additionally, within the PG, the right foot had a higher FPI score than the left foot, suggesting a tendency toward foot posture asymmetry in patients with KOA.

Supporting these findings, Chen *et al.*[19] explored the relationship between foot posture asymmetry and static stability in patients with KOA and reported that these individuals had greater foot posture asymmetry than controls, correlating with decreased static stability in the affected limb. This finding indicates that foot posture asymmetry may contribute to the balance challenges in patients with KOA. Notably, Chen's study, which focused on patients with KL grades 3 and 4, did not observe significant differences in pronation or asymmetry due to advanced deformities associated with severe KOA.

Furthermore, H. Iijima *et al.*[20] identified an association between bilateral flat feet and increased knee pain in patients with KOA, emphasizing the impact of foot alignment on symptom severity. Similarly, research by Prajakta Gosavi *et al.*[10] found that patients with KOA exhibit more pronounced foot pronation than healthy controls, supporting the link between altered foot posture and KOA.

Association between Foot Posture Asymmetry, Dynamic Stability, and Disability

A weak positive association was observed between FPI on the left foot and mWOMAC scores, suggesting that individuals with greater foot posture asymmetry may experience slightly higher levels of disability, as indicated by the mWOMAC scores. This finding implies that foot posture asymmetry may contribute to functional limitations and disability in individuals with primary osteoarthritis, although the weak association suggests that foot posture asymmetry alone is not a strong predictor of disability.

Supporting our findings, Zainab Al-Bayati *et al.*[6] reported an association between foot posture and knee osteoarthritis, noting that individuals with supinated feet tend to experience increased knee pain, functional limitations, reduced medial joint space width, and a higher condylar plateau angle. Similarly, Sweelam *et al.*[21] found that pronated foot posture significantly affects the physical function subscale of the WOMAC index in patients with KOA, further linking foot posture to functional impairment. Additionally, Zeng *et al.*[22] highlighted asymmetries in muscle strength, proprioception, biomechanics, and postural stability in individuals with unilateral knee osteoarthritis, emphasizing the multifactorial aspects of functional limitations in KOA.

However, this study did not identify a significant association between FPI and Sensamove performance in either the PG or CG, suggesting that foot posture asymmetry alone may not directly affect dynamic stability, as measured by Sensamove performance. This finding highlights that dynamic stability in KOA is likely influenced by multiple factors beyond foot posture asymmetry, such as muscle strength, joint stability, and proprioceptive

function, which may play a substantial role in an individual's ability to maintain dynamic stability.

The findings of this study are limited by the sample size and its specific geographic population, which may affect the generalizability to broader KOA populations. Future research with larger, more diverse samples and longitudinal designs is recommended to validate these findings and further investigate the potential benefits of foot posture correction and stability exercises in KOA management.

CONCLUSION

This study found a very weak to moderate association between foot posture asymmetry, dynamic stability, and disability in the Gujarati adult population with KOA. Pronated foot posture and reduced dynamic stability were significantly more prevalent among patients with KOA and correlated with functional impairment.

Conflict of Interests: None

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