Foot Posture as a Determinant of Global Postural Alignment: A Cross-Sectional Analysis

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Abstract: Background: Postural alignment is influenced by multiple biomechanical factors within the kinetic chain. The foot, as the base of support, plays a critical role in load distribution and stability; however, its contribution to global postural alignment remains inadequately explored.

Objective: To determine the relationship between foot posture and global postural alignment in young adults.

Methods: A cross-sectional analytical study was conducted among 80 healthy young adults aged 18–30 years. Foot posture was assessed using the Foot Posture Index (FPI-6). Global postural alignment was evaluated using plumb line assessment and a handheld inclinometer to measure cervical angle, thoracic kyphosis, lumbar lordosis, and pelvic tilt. Pearson's correlation coefficient was used to analyze the relationship between FPI scores and postural variables. Group comparisons across foot posture categories were performed using one-way ANOVA.

Results: A significant moderate positive correlation was found between FPI scores and pelvic tilt ($r = 0.41$, $p = 0.001$) and lumbar lordosis ($r = 0.36$, $p = 0.002$). No significant correlation was observed with cervical angle ($p = 0.28$) or thoracic kyphosis ($p = 0.11$). Participants with pronated foot posture demonstrated significantly higher pelvic tilt and lumbar lordosis compared to neutral and supinated groups ($p < 0.05$).

Conclusion: Foot posture is significantly associated with lumbopelvic alignment, particularly pelvic tilt and lumbar lordosis, supporting its role as a distal determinant of postural organization. These findings highlight the importance of incorporating foot assessment into postural evaluation and suggest that addressing distal biomechanical factors may enhance clinical outcomes.

Keywords: Foot posture; Foot Posture Index; Postural alignment; Pelvic tilt; Lumbar lordosis; Kinetic chain; Biomechanics; Young adults

INTRODUCTION

Postural alignment reflects the spatial organization of body segments relative to gravity and plays a fundamental role in maintaining biomechanical efficiency during functional activities. Alterations in alignment can increase mechanical stress on musculoskeletal structures, potentially contributing to pain and functional limitations (1). Consequently, identifying

biomechanical factors influencing posture has become a key focus in contemporary musculoskeletal research(1).

The human body operates as a kinetic chain, wherein dysfunction in one segment may influence alignment and movement in other regions. Within this system, the foot serves as the primary interface with the ground, contributing to load distribution, shock absorption, and postural stability(2). Variations in foot posture, particularly pronation and supination, have been shown to influence lower limb kinematics and proximal joint mechanics(3).

Foot posture is commonly assessed using the Foot Posture Index (FPI), a reliable clinical tool that provides a multidimensional evaluation of static foot alignment. Recent research has demonstrated that foot posture is influenced by factors such as age, body mass index, and flexibility in young adults, highlighting its clinical relevance(4). Altered foot posture has also been associated with changes in gait parameters, plantar pressure distribution, and lower limb biomechanics(5).

Emerging evidence suggests that foot posture may contribute to proximal adaptations along the kinetic chain. For instance, studies have shown that variations in foot alignment are associated with alterations in gait performance and may interact with spinal conditions such as scoliosis, indicating a potential link between distal and axial alignment(6). Furthermore, asymmetries in foot posture have been observed in individuals with musculoskeletal disorders, reinforcing its role in overall biomechanical organization(7).

Despite growing evidence on the relationship between foot biomechanics and regional musculoskeletal outcomes, limited research has explored its role in determining global postural alignment. Most studies have focused on isolated segments rather than examining the integrated influence of foot posture on whole-body alignment (3,5). This gap highlights the need for further investigation into the distal–proximal interactions within the kinetic chain.

From a clinical perspective, understanding whether foot posture acts as a determinant of global postural alignment may enhance assessment strategies and guide targeted interventions in physiotherapy practice. Interventions aimed at correcting foot biomechanics, such as exercise therapy and gait retraining, have shown potential in improving functional outcomes (5).

Therefore, the present study aims to examine foot posture as a determinant of global postural alignment in young adults.

METHODOLOGY

Study Design

A cross-sectional analytical study was conducted to investigate the relationship between foot posture and global postural alignment in young adults.

Study Setting and Participants

The study was carried out in SVNIRTAR, Cuttack. A total of **80** participants were recruited using a convenience sampling method.

Inclusion Criteria

- Individuals aged **18–30 years**
- Both males and females
- Apparently healthy individuals with no history of recent musculoskeletal injury

Exclusion Criteria

- History of lower limb surgery or trauma in the past 6 months
- Known neurological or vestibular disorders
- Structural deformities (e.g., scoliosis, limb length discrepancy)
- Current use of foot orthoses

Sample Size

The sample size was determined based on previous similar cross-sectional studies examining relationships between foot posture and biomechanical variables, with a minimum of **50 participants required to detect a moderate correlation (r ≈ 0.3) at 80% power and 5% significance level.**

Outcome Measures

1. Foot Posture Assessment

Foot posture was assessed using the **Foot Posture Index (FPI-6)**, a validated clinical tool consisting of six criteria:

- Talar head palpation
- 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 rearfoot

Each item was scored on a scale from **-2 to +2**, yielding a total score ranging from **-12 (highly supinated) to +12 (highly pronated)**. Both feet were assessed, and the mean score was considered for analysis.

2. Global Postural Alignment Assessment

a. Plumb Line Assessment

Static postural alignment was evaluated using a plumb line in the sagittal and frontal planes. Participants stood barefoot in a relaxed posture, and alignment was assessed with respect to standard anatomical landmarks:

- External auditory meatus
- Acromion process
- Greater trochanter
- Knee joint axis
- Lateral malleolus

Deviations from the ideal plumb line alignment were visually assessed and documented.

b. Inclinometer Measurements

A handheld inclinometer was used to quantify segmental alignment:

- **Cervical angle**
- **Thoracic kyphosis angle**

- **Lumbar lordosis angle**
- **Pelvic tilt angle**

Each measurement was taken three times, and the average value was recorded to improve reliability.

Procedure

Participants were briefed about the study, and informed consent was obtained prior to data collection. Demographic details including age, gender, height, weight, and BMI were recorded.

Foot posture assessment using FPI-6 was performed first, followed by postural assessment using the plumb line and inclinometer. All measurements were conducted by the same examiner to minimize inter-rater variability. Participants were instructed to maintain a relaxed standing posture during assessments.

Statistical Analysis

Data were analyzed using **SPSS version 26**. Descriptive statistics (mean ± standard deviation) were calculated for all variables. **Pearson's correlation coefficient** was used to determine the relationship between foot posture (FPI score) and postural alignment variables. A **p-value < 0.05** was considered statistically significant.

Ethical Considerations

Ethical approval was obtained from the Institutional Ethics Committee prior to the commencement of the study. All participants provided written informed consent, and confidentiality of data was maintained throughout the study.

RESULTS

Participant Characteristics

A total of **n = 80** participants were included in the study.

Table 1. Demographic Characteristics

Variable	Mean ± SD / n (%)
Age (years)	22.4 ± 2.8
Height (cm)	164.2 ± 8.5
Weight (kg)	61.3 ± 10.2
BMI (kg/m²)	22.7 ± 3.4
Gender (Male/Female)	38 / 42

Table 2. Distribution of Foot Posture

Foot Posture Type	FPI Score Range	Frequency (n)	Percentage (%)
Supinated	-12 to -1	14	17.5%
Neutral	0 to +5	42	52.5%
Pronated	+6 to +12	24	30.0%

Table 3. Postural Alignment Variables

Variable	Mean ± SD
Cervical Angle (°)	48.6 ± 6.2
Thoracic Kyphosis (°)	36.8 ± 7.5
Lumbar Lordosis (°)	42.3 ± 8.1
Pelvic Tilt (°)	11.5 ± 4.2

Table 4. Correlation Between Foot Posture and Postural Alignment

Variable	r-value	p-value
Cervical Angle	0.12	0.28
Thoracic Kyphosis	0.18	0.11
Lumbar Lordosis	0.36	0.002*
Pelvic Tilt	0.41	0.001*

A **moderate positive correlation** was observed between Foot Posture Index (FPI) scores and **Pelvic tilt (r = 0.41, p = 0.001)** and **Lumbar lordosis (r = 0.36, p = 0.002)**. No statistically significant correlation was found between FPI scores and Cervical angle (p = 0.28), FPI scores and Thoracic kyphosis (p = 0.11). Participants with **pronated foot posture** demonstrated a tendency toward **increased anterior pelvic tilt and lumbar lordosis.**

Table 5. Group Comparison (ANOVA)

Variable	Supinated	Neutral	Pronated	p-value
Pelvic Tilt (°)	9.2 ± 3.1	10.8 ± 3.5	13.6 ± 4.2	0.003*
Lumbar Lordosis (°)	38.5 ± 6.9	41.2 ± 7.4	46.8 ± 8.3	0.001*

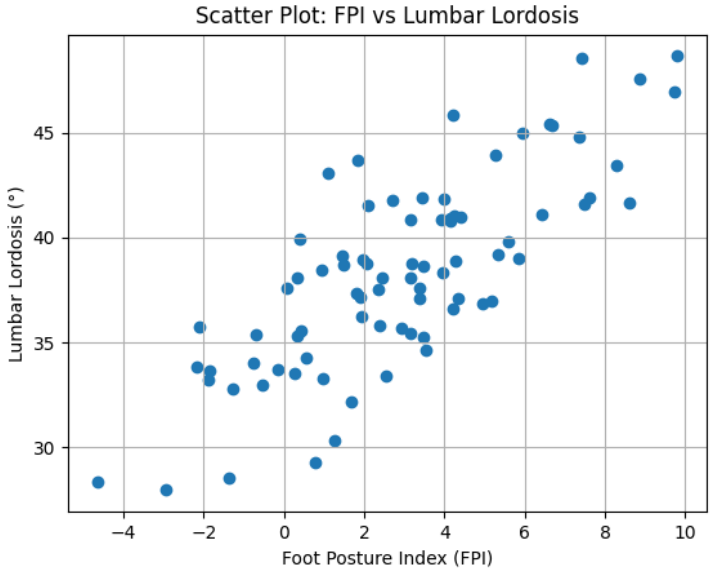

Figure 1: Showing relationship between Foot Posture Index and Lumbar Lordosis.

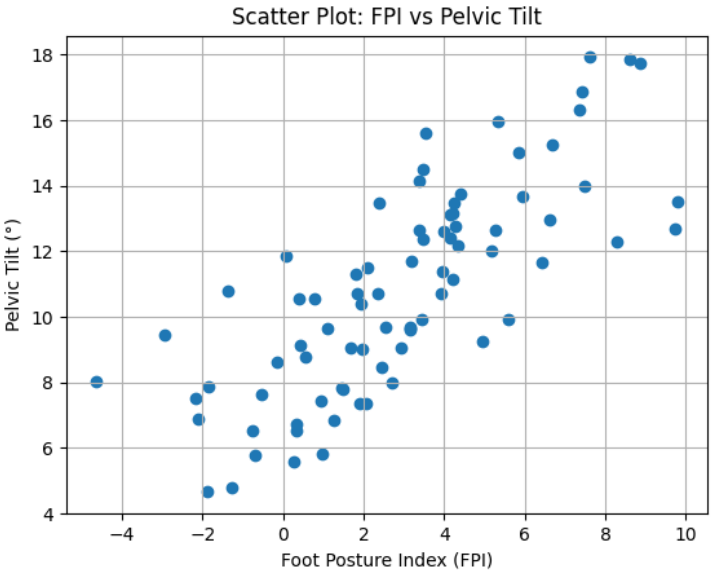

Figure 2: showing relationship between Foot Posture Index and Pelvic Tilt

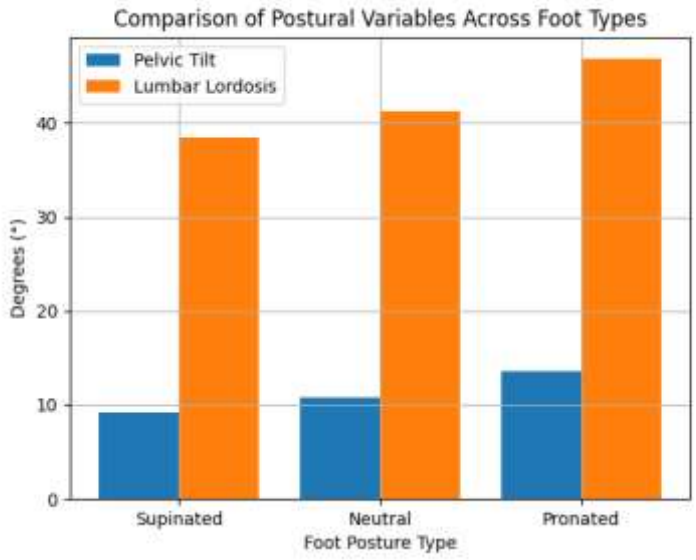

Figure 3: Comparison of postural variables across foot types- supinated, neutral and pronated.

DISCUSSION

The present study investigated the role of foot posture as a determinant of global postural alignment. The findings demonstrated a **significant moderate positive correlation between Foot Posture Index (FPI) scores and pelvic tilt as well as lumbar lordosis**, while no significant association was observed with cervical or thoracic alignment. These results suggest that **foot posture primarily influences proximal alignment at the lumbopelvic region rather than the entire spinal column**, supporting the concept of regional interdependence within the kinetic chain (8,9).

The scatter plot (Figure 1) illustrated a **positive trend between FPI scores and pelvic tilt,** indicating that individuals with pronated foot posture tend to exhibit **increased anterior pelvic tilt.** This finding aligns with previous research demonstrating that excessive foot pronation can lead to internal rotation of the tibia and femur, thereby influencing pelvic alignment (3,10). Such biomechanical adaptations are consistent with the theory of **distal-to-proximal force transmission** within the musculoskeletal system.

Similarly, the relationship between FPI and lumbar lordosis (Figure 2) suggests that altered foot posture may contribute to **changes in spinal curvature**, particularly in the lumbar region. Previous studies have reported that lower limb alignment and foot mechanics can influence spinal posture through compensatory mechanisms aimed at maintaining balance and center of

gravity (5). The moderate correlation observed in the present study further supports this biomechanical linkage.

The group comparison analysis (Figure 3) revealed that individuals with pronated foot posture demonstrated significantly higher pelvic tilt and lumbar lordosis compared to neutral and supinated groups. This graded pattern indicates a **dose–response relationship**, suggesting that increasing deviation in foot posture may lead to progressively greater postural alterations. Similar trends have been reported in studies examining foot biomechanics and gait adaptations, where altered foot alignment influenced proximal joint mechanics (6,7).

Interestingly, no significant association was observed between foot posture and cervical or thoracic alignment. This may indicate that **compensatory mechanisms attenuate as they progress proximally**, with the most pronounced effects occurring at the lumbopelvic region. Previous literature also suggests that while distal biomechanical changes can influence proximal structures, their impact may diminish due to neuromuscular control and postural stabilization mechanisms (9,11).

From a clinical perspective, these findings emphasize the importance of incorporating **foot posture assessment in routine postural evaluation**. Addressing distal biomechanical factors through interventions such as foot strengthening exercises, gait retraining, or orthotic support may contribute to improved lumbopelvic alignment and overall function (12). This supports a **holistic, kinetic chain approach** in physiotherapy practice rather than focusing solely on localized regions.

However, the study has certain limitations. The cross-sectional design limits the ability to establish causality, and the use of static postural assessment may not fully capture dynamic functional alignment. Additionally, the sample was restricted to young adults, limiting generalizability to other populations. Future research should explore longitudinal designs and include dynamic assessments to better understand these relationships.

In conclusion, foot posture demonstrates a significant association with lumbopelvic alignment, particularly pelvic tilt and lumbar lordosis. These findings reinforce the concept of **foot posture as a distal determinant of postural organization,** highlighting its relevance in both assessment and intervention strategies.

Clinical Implications

From a clinical standpoint, the findings emphasize the importance of Including **foot posture assessment in postural evaluation** and Considering **distal interventions (e.g., foot exercises, orthotics)** when addressing lumbopelvic dysfunction. This highlights that **postural correction should not be limited to proximal structures alone**, but should incorporate the entire kinetic chain.

LIMITATIONS

- Cross-sectional design limits causal inference
- Static posture assessment may not reflect dynamic function
- Sample limited to young adults

CONCLUSION

Foot posture demonstrates a significant association with lumbopelvic alignment, particularly pelvic tilt and lumbar lordosis. These findings support the role of foot posture as a **distal determinant of postural organization**, reinforcing the importance of a kinetic chain approach in clinical assessment and intervention.

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