International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 19s, 2025
https//theaspd.com/index.php

Comparative Analysis of Foot Posture Index (FPI-6) Between Athletes and Laymen: Implications for Biomechanical Adaptations in High-Impact Sports

Gopal Krishna Shukla[1], Dr. B. C. Kapri[2], Dr. Binayak Kumar Dubey[3]
[1]Research Scholar, Department of Physical Education, Faculty of Arts, Banaras Hindu University, Varanasi - 221005, India.
[2]Senior Professor, Department of Physical Education, Faculty of Arts, Banaras Hindu University, Varanasi -221005, India.
[3]Assistant Professor, Department of Physical Education, Faculty of Arts, Banaras Hindu University, Varanasi -221005, India.
***Corresponding Author:**
Gopal Krishna Shukla
E-mail ID: gkshukla@bhu.ac.in

Abstract: *This study examines the biomechanical differences in foot posture between collegiate athletes participating in high-impact sports and non-athletic individuals, utilizing the Foot Posture Index (FPI-6) as a standardized assessment tool. A total of thirty participants from each group were evaluated across six criteria, focusing on both rearfoot and forefoot alignment parameters. The analysis revealed that non-athletic individuals exhibited significantly more pronated foot postures compared to athletes, particularly in areas such as talar head palpation, medial arch congruence, and malleolar curvature. These postural differences may increase the risk of musculoskeletal disorders, including plantar fasciitis and Achilles tendinopathy, in non-athletic individuals. Conversely, athletes displayed postural adaptations that suggest enhanced structural stability, likely resulting from the repeated mechanical loading and neuromuscular conditioning associated with their participation in sports. Interestingly, no significant differences were observed in calcaneal inversion/eversion or talonavicular joint prominence, indicating that certain components of foot structure might be less responsive to functional adaptations. The results of this study highlight the utility of the FPI-6 as an effective diagnostic and preventive screening tool across both clinical and sports environments. They also emphasize the need for individualized assessment protocols tailored to injury prevention and performance enhancement. Future research is encouraged to include longitudinal and sport-specific studies further to clarify the connection between athletic training and foot morphology.*
Keywords: *Foot Posture Index (FPI-6), Biomechanical Adaptation, High-Impact Sports, Pronation and Supination, Athletic Screening, Musculoskeletal Injury Prevention*

INTRODUCTION

Foot posture is a fundamental aspect of biomechanics, particularly within sports and movement sciences, as it has a significant impact on performance, stability, and injury risk (Buldt et al., 2015). When foot alignment is compromised, it may lead to altered kinetic chains and compensatory movement patterns, which can increase the likelihood of musculoskeletal injuries (Tiberio, 1987; Neal et al., 2014). Therefore, evaluating foot posture is a critical component of clinical assessments and athletic screening protocols, particularly in high-impact sports that involve running, jumping, and rapid directional changes (Nigg et al., 1993).

High-impact sports subject the lower limbs to repetitive loads that can reach 5 to 10 times an athlete's body weight (Cavanagh & Lafortune, 1980). This can result in adaptations within the musculoskeletal system, especially in adolescents with developing structures (Dowling et al., 2001; Di Michele & Merni, 2014). Such adaptations may lead to structural changes in the foot, affecting factors such as arch height, joint mobility, and muscle function (Muller et al., 2010).

Despite increasing recognition of the importance of foot posture, the existing literature presents limited and at times conflicting evidence regarding the influence of athletic participation on foot structure (Cain et al., 2007). Some studies have shown no significant differences in foot posture between athletes and non-athletes (Hawes et al., 1992), while others have identified sport-specific patterns. For example, gymnasts and handball players often demonstrate lower medial longitudinal arches, indicative of more pronated foot types (Hegazy et al., 2014; Khamis & Yizhar, 2007). Conversely, wrestlers frequently display higher arch indices, which suggest supinated foot types (Dugan et al., 2005).

These inconsistencies may arise from a lack of specificity in sport classification or failure to consider the mechanical loading profiles associated with different sports. Research conducted by Zifchock et al. (2006) emphasizes the need for categorizing sports based on their biomechanical impacts to interpret findings accurately. There is a growing consensus that the influence of various sports on foot morphology can differ significantly based on factors such as intensity, surface, and movement demands (Brukner & Khan, 2012; Reilly et al., 2009).

The assessment of foot posture has evolved significantly, moving from rudimentary footprint analyses to standardized methods such as the Foot Posture Index (FPI). The FPI-6 evaluates six distinct criteria on a scale from -2 (supinated) to +2 (pronated), integrating both static and dynamic measures of foot alignment (Redmond et al., 2006). The intra-rater reliability of the FPI-6 is high, while its inter-rater reliability is moderate but remains acceptable for clinical and field applications (Cornwall & McPoil, 1999; Keenan et al., 2007). Furthermore, the FPI-6 has demonstrated strong validity with respect to correlations with motion capture and radiographic techniques (Hill et al., 2006).

Recent investigations have employed the FPI-6 to assess diverse populations, including athletes (Teyhen et al., 2009), individuals experiencing patellofemoral pain (Barton et al., 2011), and those with flatfoot conditions (Evans et al., 2003). These applications underscore the FPI-6's versatility and reliability as a diagnostic and screening tool.

The present study aims to examine whether collegiate athletes participating in high-impact sports exhibit distinct foot posture profiles compared to their non-athletic counterparts, utilizing the FPI-6 as a validated assessment instrument. The hypothesis underpinning this research posits that repetitive mechanical loading resulting from sports participation may lead to increased foot pronation, driven by ligamentous laxity and adaptive changes over time (Kirby, 2001).

METHODS

Participants: In the present study, a convenience sampling method was utilized to recruit participants from the target population. The research involved two distinct groups: one comprising sportspersons and the other consisting of non-sportspersons. A total of 30 individuals were purposefully selected for each group.

The sportsperson group consisted of university students who were members of varsity teams and had actively participated in inter-university and national-level competitions in various sports, including badminton, athletics, and football. In contrast, the Laymen group consisted of individuals from multiple backgrounds, including corporate workers, office workers, and shopkeepers. This structured approach facilitated a comprehensive analysis of physical engagement and its implications across both groups.

Variable: The foot posture of both sportspeople and laymen was considered as a primary variable for this study.

Procedure: The assessment begins with the participant standing in a relaxed posture, ensuring that their weight is evenly distributed across both feet. The participant needs to maintain stillness, with their arms resting naturally at their sides and their gaze fixed straight ahead. To establish a comfortable stance, the participant may be encouraged to take several steps in place before settling into position.

Throughout the assessment, the participant must avoid turning or twisting to observe the process, as such movements could affect the alignment of their feet. The participant should remain stationary for approximately two minutes while the assessment is conducted. The assessor will require the ability to move

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 19s, 2025
https//theaspd.com/index.php

freely around the participant to ensure unobstructed access to the back of the legs and feet during the evaluation. **Criterion measures**

below the malleoli	malleolus, either straight or convex	malleolus is concave, but flatter/ shallower than the curve above the malleolus	supra malleolar curves are roughly equal	the malleolus is more concave than the curve above the malleolus	the malleolus is markedly more concave than the curve above the malleolus
Calcaneal inversion/ eversion	More than an estimated 5° inverted (varus)	Between vertical and an estimated 5° inverted (varus)	Vertical	Between vertical and an estimated 5° everted (valgus)	More than an estimated 5° everted (valgus)
Forefoot Score	-2	-1	0	1	2
Talo-navicular congruence	The area of TN J is markedly concave	Area of TNJ is slightly concave	Area of TNJ flat	Area of TNJ bulging slightly	Area of TNJ bulging markedly
Medial arch height	Arch high and acutely angled towards the posterior end of the medial arch	Arch moderately high and slightly acute posteriorly	Arch height is normal and concentrically curved	Arch lowered with some flattening in the central portion	Arch is very low with severe flattening in the central portion arch making ground contact
Forefoot abduction/ adduction	No lateral toes visible. Media toes are visible	Medial toes are more visible than the lateral ones.	Medial and latera toes are equally visible	Lateral toes are more visible than medial	No medial toes visible. Lateral toes are visible
Rearfoot Score	-2	-1	0	1	2
Talar head palpation	Talar head palpable on the lateral side/bu not on the medial side	Talar head palpable on the latera t side/slightly palpable on the medial side	The talar head is equally palpable on the lateral and medial sides	Talar head slightly palpable on the lateral side/ palpable on the medial side	Talar head not palpable on the lateral side/ but palpable on the medial side
Curves above and	Curve below the	The curve below the	Both infra and	The curve below	The curve below

Statistical Technique

For data analysis, we utilized JAMOVI, IBM SPSS 24, and Microsoft Excel as primary tools. Descriptive statistics were employed to provide a comprehensive understanding of the dataset. To facilitate the comparison of groups based on the Foot Posture Index, an independent sample t-test was conducted, adhering to a 95% confidence interval.

Analysis of Data and Results

Table 1: Presents the descriptive statistics of the foot posture index among laymen and sportspersons

	Group	N	Mean	Std. Deviation	Std. Error Mean
Taler Head Palpation	Laymen	30	.3333	1.18419	.21620
	sports persons	30	-.4000	1.54474	.28203
Curves above and below the lateral malleolus	Laymen	30	1.1667	.79148	.14450
	sports persons	30	-.2000	1.03057	.18815
Inversion/eversion of the calcaneus	Laymen	30	-.3000	1.14921	.20982
	sports persons	30	.0667	1.43679	.26232
Prominence in the region of the TNJ	Laymen	30	-.4000	1.40443	.25641
	sports persons	30	.1000	1.21343	.22154
Congruence of the medial longitudinal arch	Laymen	30	1.4333	.77385	.14129
	sports persons	30	.9000	.92289	.16850
Abduction/adduction of the forefoot on the rearfoot	Laymen	30	.7667	.93526	.17075
	sports persons	30	.9333	1.14269	.20863

Table 1 provides an overview of the descriptive statistics for the six components of the Foot Posture Index (FPI) evaluated across two distinct cohorts: sportspersons and laymen, with each group comprising 30 participants. The statistics presented include the mean (M), standard deviation (SD), and standard error of the mean (SEM), offering a valuable framework for comparative analysis of foot posture characteristics. The findings indicate that laymen exhibited higher mean scores across several FPI components, suggesting a greater tendency toward pronation. For instance, in the Talar Head Palpation assessment, laymen recorded a mean score of 0.33 (SD = 1.18), while sportspersons had a mean of -0.40 (SD = 1.54). Furthermore, in the measurement of Curves Above and Below the Lateral Malleolus, the layperson group registered a mean of 1.17 (SD = 0.79) compared to -0.20 (SD = 1.03) for sportspersons. The evaluation of the Congruence of the Medial Longitudinal Arch also reflected these patterns, with laymen achieving a mean score of 1.43 (SD = 0.77), in contrast to sportspersons, who had a mean of 0.90 (SD = 0.92). In contrast, sportspersons displayed higher mean values in the components associated with neutral or supinated postural characteristics. For example, in the Inversion/Eversion of the Calcaneus, sportspersons had a mean of 0.07 (SD = 1.44), while laymen had a mean of -0.30 (SD = 1.15). When assessing the Prominence in the Region of the Talonavicular Joint (TNJ), sportspersons recorded a mean of 0.10 (SD = 1.21), whereas laymen had a mean of -0.40 (SD = 1.40). Additionally, the Abduction/Adduction of the Forefoot on the Rearfoot component showed that sportspersons had a mean of 0.93 (SD = 1.14), compared to 0.77 (SD = 0.94) for laymen.

These descriptive statistics underscore significant morphological differences between the two groups, with laymen exhibiting postural characteristics more consistent with foot pronation.

Table 2: Presents the Independent sample t-test describing the comparison between the Laymen and the sportspersons

Independent Samples Test

	Levene's Test f Equality of Variances		t-test for Equality of Means				
	F	Sig.	t	df	Sig. (2tailed)	Mean Difference	Std. Error Difference
Taler Head Palpation	6.864	.011	2.064	58	.044	.73333	.35536
Curves above and below the lateral malleolus	4.903	.031	5.761	58	.000	1.36667	.23724
Inversion/eversion of the calcaneus	1.093	.300	-1.092	58	.280	-.36667	.33591
Prominence in the region of the TNJ	2.872	.096	-1.476	58	.145	-.50000	.33886
Congruence of the medial longitudinal arch	.052	.820	2.425	58	.018	.53333	.21989
Abduction/adduction of the forefoot on the rearfoot	.497	.484	-.618	58	.539	-.16667	.26960

To conduct a statistical evaluation of the differences between groups in the components of the Foot Posture Index (FPI), independent samples t-tests were performed, as outlined in Table 2. The assumption of homogeneity of variances was assessed through Levene's Test. In instances where this assumption was not met ($p < .05$), appropriate adjustments to the degrees of freedom were made.

Significant differences were identified in the following FPI variables:

- Talar Head Palpation: t (58) = 2.06, p = .044. Laypersons demonstrated significantly higher scores compared to sportspersons, with a mean difference of 0.73 (SE = 0.36).
- Curves Above and Below the Lateral Malleolus: t (58) = 5.76, $p < .001$. This notable difference (Mean Difference = 1.37, SE = 0.24) highlights a significantly more pronounced lateral curvature among laypersons.
- Congruence of the Medial Longitudinal Arch: t (58) = 2.43, p = .018. The mean difference of 0.53 (SE = 0.22) also favoured laypersons.

The remaining variables did not achieve statistical significance:

- Inversion/Eversion of the Calcaneus: t (58) = -1.09, p = .280.
- Prominence in the Region of the Talonavicular Joint: t (58) = -1.48, p = .145.
- Abduction/Adduction of the Forefoot on the Rearfoot: t (58) = -0.62, p = .539.

These inferential findings highlight specific postural characteristics, where foot morphology exhibits significant differences between physically active and inactive populations.

DISCUSSION

The results of this investigation provide compelling evidence that athletic engagement is a key factor in developing more structurally aligned foot postures. Prior studies, such as those conducted by Cain et al. (2007), have documented that regular mechanical loading experienced by athletes contributes to adaptive changes in foot architecture. These adaptations are crucial as they help mitigate excessive pronation, a common biomechanical issue that can lead to various injuries if left unaddressed. Furthermore, Cote et al. (2005) found that collegiate athletes exhibit increased dynamic control and enhanced neuromuscular integration in their medial longitudinal arch. This improvement is likely due to task-specific biomechanical conditioning that occurs during training and competition, enabling athletes to better manage the stresses placed on their feet.

In our study, the lay cohort demonstrated significant pronation when evaluated through various assessments, including talar palpation, malleolar curvature, and arch congruence. This pronounced pronation raises concerns about a predisposition to overuse pathologies, such as plantar fasciitis or Achilles tendinopathy. These findings are consistent with Buldt et al. (2015), who established a connection between increased levels of pronation and heightened mechanical strain, which can lead to musculoskeletal dysfunction over time.

Additionally, it is worth noting that the study found no significant changes in calcaneal inversion and the prominence of the talonavicular joint (TNJ). This outcome aligns with the observations made by Redmond et al. (2006), who suggested that specific components of the Foot Posture Index (FPI) may be less sensitive to changes resulting from functional adaptations and may instead reflect an individual's congenital morphology. Such insights imply that while some aspects of foot posture can be influenced by physical activity, others may be intrinsically determined.

Collectively, these results reinforce the hypothesis that long-term physical conditioning plays a vital role in fostering favorable musculoskeletal adaptations in the structural profile of the foot. This distinction between athletic individuals and their sedentary counterparts underscores the importance of regular physical activity not only for overall health but also for optimizing biomechanical function and reducing the risk of injury. As athletes continually engage in training, their mechanical loading encourages adaptive changes that can lead to better foot function and enhanced performance.

CONCLUSION

This study offers valuable insights into the biomechanical characteristics of foot posture, highlighting notable differences between athletic and non-athletic individuals. The results indicate that non-athletic individuals are more likely to demonstrate pronated foot postures, particularly concerning the structure of the medial arch and the contour of the lateral malleolus. In contrast, athletic individuals tend to exhibit postural characteristics associated with enhanced structural resilience, which may result from their consistent exposure to the physical demands inherent in their specific sports.

These findings underscore the crucial need for individualized foot posture assessments in various contexts, including injury prevention, therapeutic interventions, and performance enhancement. The Foot Posture Index (FPI-6) serves as an effective and non-invasive tool that should be routinely incorporated into athletic screening protocols.

Looking forward, future research should priorities longitudinal studies to deepen the understanding of how athletic training influences foot morphology over time. Such research should account for variables such as the type of sport, training volume, and biomechanical loading patterns.

Funding Statement

The researcher covered all expenses associated with this research.

Conflict statement

There are no conflicts of interest among the authors

REFERENCES:

1. Barton, C. J., Bonanno, D., Levinger, P., and Menz, H. B. 2011. "Foot and Ankle Characteristics in Patellofemoral Pain Syndrome: A Case Control and Reliability Study." Journal of Orthopaedic & Sports Physical Therapy 41 (4): 249–57.
2. Brukner, P., and Khan, K. 2012. Brukner & Khan's Clinical Sports Medicine. 4th ed. McGraw-Hill.
3. Buldt, A. K., Murley, G. S., Butterworth, P., Levinger, P., Menz, H. B., and Landorf, K. B. 2015. "The Relationship between Foot Posture and Lower Limb Kinematics During Walking: A Systematic Review." Gait & Posture 38 (3): 363–72.

4. Cain, L. E., Nicholson, L. L., Adams, R. D., and Burns, J. 2007. "Foot Morphology and Foot/Ankle Injury in Indoor Football." Journal of Science and Medicine in Sport 10 (5): 311–19.
5. Cavanagh, P. R., and Lafortune, M. A. 1980. "Ground Reaction Forces in Distance Running." Journal of Biomechanics 13 (5): 397–406.
6. Cornwall, M. W., and McPoil, T. G. 1999. "Reliability and Validity of Center of Pressure Quantification in Foot Posture Assessment." Journal of the American Podiatric Medical Association 89 (6): 272–77.
7. Cote, K. P., Brunet, M. E., Gansneder, B. M., and Shultz, S. J. 2005. "Effects of Pronated and Supinated Foot Postures on Static and Dynamic Postural Stability." Journal of Athletic Training 40 (1): 41–46.
8. Di Michele, R., and Merni, F. 2014. "The Concurrent Effects of Strike Pattern and Ground-Contact Time on Running Economy." Journal of Science and Medicine in Sport 17 (4): 414–18.
9. Dowling, A. M., Steele, J. R., and Baur, L. A. 2001. "What Are the Effects of Obesity in Children on Plantar Pressure Distributions?" International Journal of Obesity 25 (5): 845–52.

Dugan, S. A., and Bhat, K. P. 2005. "Biomechanics and Analysis of Running Gait." Physical Medicine and Rehabilitation Clinics 16 (3): 603–21.

10. Evans, A. M., Copper, A. W., and Scharfbillig, R. 2003. "Reliability of the Foot Posture Index and Traditional Measures of Foot Position." Journal of the American Podiatric Medical Association 93 (3): 203–13.
11. Hawes, M. R., Sovak, D., Miyashita, M., Kang, S. J., Yoshihuku, Y., and Tanaka, S. 1992. "Ethnic Differences in Forefoot Shape and the Determination of Shoe Comfort." Ergonomics 35 (3): 327–34.
12. Hegazy, F. A., Hegazy, R. A., and El-Shazly, A. A. 2014. "Relationship Between Foot Arch Index and Dynamic Balance Among Handball Players." International Journal of Sports Science and Engineering 8 (1): 43–48.
13. Hill, M., Naemi, R., and Chockalingam, N. 2006. "Reliability of the Foot Posture Index (FPI-6): A Review." The Foot 16 (4): 205–13.
14. Keenan, A. M., Redmond, A. C., Horton, M., Conaghan, P. G., and Tennant, A. 2007. "The Foot Posture Index: Rasch Analysis of a Novel, Foot-Specific Outcome Measure." Archives of Physical Medicine and Rehabilitation 88 (1): 88–93.
15. Khamis, S., and Yizhar, Z. 2007. "Effect of Foot Hyperpronation on Pelvic Alignment in a Standing Position." Gait & Posture 25 (1): 127–34.
16. Kirby, K. A. 2001. "Biomechanics of the Normal and Abnormal Foot." Journal of the American Podiatric Medical Association 91 (10): 507–12.
17. Muller, S., Carlsohn, A., Muller, J., and Baur, H. 2010. "Foot Posture and Functional Performance in Children Aged 11 to 14 Years." Deutsche Zeitschrift für Sportmedizin 61 (7-8): 192–97.
18. Neal, B. S., Griffiths, I. B., Dowling, G. J., Murley, G. S., Munteanu, S. E., and Franettovich Smith, M. M. 2014. "Foot Posture as a Risk Factor for Lower Limb Overuse Injury: A Systematic Review and Meta-Analysis." Journal of Foot and Ankle Research 7 (1): 55.
19. Nigg, B. M., Bahlsen, H. A., Luethi, S. M., and Stokes, S. 1993. "The Influence of Running Velocity and Midsole Hardness on External Impact Forces in Heel-Toe Running." Journal of Biomechanics 20 (10): 951–59.
20. Redmond, A. C., Crosbie, J., and Ouvrier, R. A. 2006. "Development and Validation of a Novel Rating System for Scoring Standing Foot Posture: The Foot Posture Index." Clinical Biomechanics 21 (1): 89–98.
21. Reilly, T., Bangsbo, J., and Franks, A. 2009. "Anthropometric and Physiological Predispositions for Elite Soccer." Journal of Sports Sciences 18 (9): 669–83.
22. Teyhen, D. S., Stoltenberg, B. E., Collinsworth, K. M., Giesel, C. L., Williams, D. G., and Molloy, J. M. 2009. "Dynamic Plantar Pressure Parameters Associated with Static Arch Height Index During Gait." Clinical Biomechanics 24 (4): 391–96.
23. Tiberio, D. 1987. "Pathomechanics of Structural Foot Deformities." Physical Therapy 67 (10): 1501–04.
24. Zifchock, R. A., Davis, I., and Hamill, J. 2006. "Kinetic Asymmetry in Female Runners with and Without Retrospective Tibial Stress Fractures." Journal of Biomechanics 39 (15): 2792–97.