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Original Article

The Influence of Metatarsalgia on Functional Independence in Young Athletes with Varying Levels of Physical Activity and Socioeconomic Status

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ABSTRACT

Background: Metatarsalgia is a prevalent forefoot disorder contributing to pain, disability, and reduced mobility, particularly among physically active populations. Although primarily studied in older adults and patients with systemic conditions, little is known about its impact on functional independence in young athletes, a group potentially vulnerable due to biomechanical loading, sport-specific stresses, and socioeconomic disparities. Objective: To determine the influence of metatarsalgia on functional independence among young athletes aged 18–35 years with varying levels of physical activity and socioeconomic status. Methods: A cross-sectional study enrolled 169 athletes diagnosed with metatarsalgia involving the lesser metatarsals. Participants completed the validated Foot Function Index (FFI) questionnaire assessing pain, disability, and activity limitation. Demographic and biomechanical variables including age, gender, BMI, foot type, and socioeconomic status were recorded. Statistical analysis used Spearman's correlation with a significance threshold of $p<0.05$. Results: The mean overall FFI score was 38.15% (SD ±5.82), indicating moderate impairment. Significant positive correlations were observed between FFI and BMI ($\rho=0.613$, $p=0.008$) and foot type abnormality ($\rho=0.515$, $p=0.035$), while gender was negatively correlated ($\rho=-0.213$, $p=0.005$), indicating greater impairment among females. Age was not significantly correlated ($\rho=0.123$, $p=0.111$). Conclusion: Metatarsalgia in young athletes is associated with moderate foot-related disability, particularly among females, those with elevated BMI, and those with abnormal foot types, underscoring the need for individualized preventive and rehabilitative strategies.

Keywords: metatarsalgia, foot pain, functional independence, young athletes, BMI, foot type, socioeconomic status

INTRODUCTION

Metatarsalgia, characterized by localized forefoot pain under one or more metatarsal heads, is a biomechanical condition that has profound implications for mobility and quality of life in active individuals. Its pathophysiology involves complex interactions between anatomical alignment, plantar loading patterns, and dynamic forces during gait (1). Studies have shown that hallux valgus, forefoot structural abnormalities, and variations in metatarsal lengths predispose individuals to abnormal plantar pressures contributing to metatarsalgia (2). While the condition is common among older adults, there is growing evidence that young athletic populations are also susceptible due to repetitive high-impact loading, footwear constraints, and sport-specific biomechanical demands (3). Conservative treatment, including metatarsal padding and footwear modifications, remains the first-line approach, but these strategies often fail in individuals with persistent mechanical overload or deformity (4). Approximately 90% of cases are attributed to biomechanical factors, underscoring the importance of understanding individualized risk profiles (5).

Despite advances in the biomechanical understanding of metatarsalgia, little is known about its impact on functional independence in young athletes, a group that relies heavily on foot function for both sports performance and daily activities. Young adults are typically assumed to possess greater physiological resilience; however, emerging data suggest that factors such as high body mass index, abnormal foot type (e.g., flat foot, pes cavus), and inadequate recovery practices may exacerbate foot dysfunction even in this population (6). Furthermore, socioeconomic status can play a critical role in determining access to early diagnosis, quality footwear, physical therapy, and rehabilitation services, thereby influencing outcomes (7). Prior research has primarily focused on elderly cohorts, individuals with rheumatoid arthritis, or post-surgical patients, with limited attention to younger, active individuals who may silently experience declines in mobility, activity levels, and quality of life due to untreated or underrecognized metatarsalgia (8).

In a cohort of adolescent DanceSport athletes, Liu et al. reported altered plantar pressure distributions associated with hallux valgus progression, highlighting the importance of foot loading patterns in sports-related foot conditions (9). Similarly, Männikkö and Sahlman

demonstrated that conservative interventions such as metatarsal padding improved pain and function in patients with metatarsalgia but emphasized that female gender and prolonged standing were associated risk factors (10). However, these studies do not address how metatarsalgia interacts with socioeconomic determinants or differences in physical activity levels among young adults. The paucity of evidence in this area represents a significant knowledge gap, as early identification and tailored intervention in athletic populations may prevent progression to chronic pain and disability.

Therefore, the present study is designed to determine the influence of metatarsalgia on functional independence in young athletes aged 18–35 years, specifically accounting for variations in physical activity levels and socioeconomic status. This investigation aims to quantify functional limitations using the validated Foot Function Index (FFI) while identifying associations with demographic and biomechanical factors including body mass index, gender, and foot type. The central hypothesis is that higher BMI, abnormal foot types, and lower socioeconomic status will be significantly associated with reduced functional independence, as measured by greater foot pain, disability, and activity limitation scores.

MATERIALS AND METHODS

This study employed a cross-sectional observational design aimed at investigating the influence of metatarsalgia on functional independence among young athletes aged 18–35 years. The research was conducted at the University Sports Club and Gym, affiliated with the University Institute of Physical Therapy, The University of Lahore. Data collection spanned four months following the formal approval of the study protocol. The rationale for this design was to provide a snapshot of associations between metatarsalgia-related foot dysfunction and key demographic, biomechanical, and socioeconomic variables in an athletic population at a single point in time.

Participants were recruited using a convenience sampling approach, justified by logistical feasibility and access to an engaged, athletic cohort. Inclusion criteria were: age between 18 and 35 years; confirmed diagnosis of metatarsalgia involving the lesser metatarsals (2nd to 5th); and duration of symptoms of at least three months, diagnosed by an orthopedic specialist according to standard definitions of primary and secondary metatarsalgia (11). Exclusion criteria comprised: history of lower limb arthritis; other mechanical pain syndromes; plantar corns; previous orthopedic foot surgery; significant comorbid medical conditions that could interfere with participation; diagnosed metabolic disorders; and the presence of heel spurs (11). Eligible participants were approached in person, provided with detailed information about the study objectives and procedures, and informed consent was obtained prior to participation. Data collection occurred on-site under supervision to ensure completeness and accuracy.

The primary outcome measure was the Foot Function Index (FFI), a validated, self-administered questionnaire designed to assess pain (9 items), disability (9 items), and activity limitation (5 items) associated with foot pathology, scored from 0 (no impairment) to 10 (severe impairment) per item (12). Scoring involved summing the item scores within each subscale, dividing by the maximum possible subscale score, and expressing as a percentage. The total FFI was derived by averaging the three subscale scores, with higher scores indicating greater functional impairment (12).

Demographic data included age, gender, BMI, socioeconomic status (categorized as low, middle, high), foot type (normal, flat, high arch), and sports participation profile. Variables were operationally defined for consistency and reproducibility. Investigator training ensured standardized assessments. Bias minimization included standardized protocols and rigorous data entry validation. Sample size was determined a priori (n=169) to achieve 95% confidence with conservative estimates (13).

Statistical analysis was performed using IBM SPSS version 26.0. Descriptive statistics summarized demographic and clinical data. Relationships between FFI scores and independent variables were assessed using Spearman's correlation. A p-value <0.05 indicated statistical significance. Ethical approval was obtained from the University Institute of Physical Therapy research ethics review board, with all participants providing written informed consent. Data were anonymized for confidentiality and securely stored to maintain integrity and reproducibility.

RESULTS

A total of 169 young athletes aged between 18 and 35 years participated in the study, with the mean age calculated as 25.91 years (SD ±5.12), reflecting a predominantly young adult population (Table 1). The gender distribution demonstrated a considerable predominance of female participants, with 112 females accounting for 66.3% and 57 males comprising 33.7% of the sample (Table 2). In terms of body mass index (BMI), over half of the study group (51.5%, n=87) were classified as overweight, 46.2% (n=78) had a normal BMI, and only 2.4% (n=4) were underweight, highlighting a trend towards higher BMI among the included athletes (Table 3).

Socioeconomic status was diverse, with 37.9% (n=64) of participants identified as low socioeconomic status, 34.9% (n=59) as middle, and 27.2% (n=46) as high, indicating a representative mix across different social strata (Table 4). Analysis of foot type showed that 43.8% (n=74) had flat feet, 39.1% (n=66) had high arches, and only 17.2% (n=29) demonstrated normal arch structure, making flat foot the most prevalent foot type among this athletic group (Table 5).

Regarding sports participation, swimming was reported by 22.5% (n=38), football by 21.3% (n=36), running and basketball each by 17.8% (n=30), and 20.7% (n=35) indicated either no sport or participation in activities other than the named sports, illustrating a broad range of athletic engagement (Table 6). The use of medication for foot pain was relatively infrequent, with 32.0% (n=54) of athletes reporting current or prior use, compared to 68.0% (n=115) who denied any history of medicated foot conditions (Table 7).

Foot function was assessed using the Foot Function Index (FFI). The pain subscale produced a mean score of 44.64 (SD ±9.51), indicating moderate foot pain among the participants (Table 8). The disability subscale yielded a similar mean score of 44.28 (SD ±10.30), reflecting a moderate level of disability associated with foot dysfunction (Table 9). The activity subscale was somewhat lower, with a mean of 25.51 (SD ±6.48), suggesting mild to moderate restriction in overall activity (Table 10). When aggregated, the overall mean FFI score was 38.15 (SD ±5.82), underscoring a moderate level of functional limitation attributable to metatarsalgia in this cohort (Table 11).

Statistical correlation analysis (Table 12) demonstrated that the FFI score was significantly positively correlated with BMI (ρ=0.613, p=0.008), indicating that as body mass index increased, so did the degree of functional impairment. A moderate positive correlation was also observed between foot type and FFI (ρ=0.515, p=0.035), signifying that participants with abnormal foot structures (flat or high arch) experienced greater dysfunction. Gender showed a significant negative correlation with FFI (ρ=–0.213, p=0.005), implying that female athletes reported more substantial impairment relative to their male counterparts. Age, however, was not significantly associated with FFI outcomes (ρ=0.123, p=0.111).

In summary, these data reveal a high prevalence of overweight status, abnormal foot structure, and moderate functional disability among young athletes with metatarsalgia, with clear associations between higher BMI, non-neutral foot type, and greater impairment in functional independence. Notably, socioeconomic status, while diverse, was not directly correlated with FFI outcomes in the main correlation analysis, though its influence may be inferred from distributional trends.

Table 1. Age Distribution of Participants

Statistic	Age (years)
Minimum	18.0
Maximum	35.0
Mean	25.91
SD	5.12

Table 2. Gender Distribution

Gender	Frequency	Percentage (%)
Male	57	33.7
Female	112	66.3

Table 3. Body Mass Index (BMI) Classification

Category	Frequency	Percentage (%)
Underweight	4	2.4
Normal	78	46.2
Overweight	87	51.5

Table 4. Socioeconomic Status

Status	Frequency	Percentage (%)
Low	64	37.9
Middle	59	34.9
High	46	27.2

Table 5. Foot Type Distribution

Foot Type	Frequency	Percentage (%)
Normal	29	17.2
High Arch	66	39.1
Flat Foot	74	43.8

Table 6. Sports Participation

Sport	Frequency	Percentage (%)
Basketball	30	17.8
Football	36	21.3
Running	30	17.8
Swimming	38	22.5
None/Other	35	20.7

Table 7. Medication Use for Foot Pain

Medication Use	Frequency	Percentage (%)
Yes	54	32.0
No	115	68.0

Table 8. Foot Function Index (Pain Subscale)

Statistic	FFI (Pain %)
Minimum	35.0
Maximum	53.0

Mean	44.64
SD	9.51

Table 9. Foot Function Index (Disability Subscale)

Statistic	FFI (Disability %)
Minimum	34.0
Maximum	54.0
Mean	44.28
SD	10.3

Table 10. Foot Function Index (Activity Subscale)

Statistic	FFI (Activity %)
Minimum	19.0
Maximum	31.0
Mean	25.51
SD	6.48

Table 11. Overall Foot Function Index

Statistic	FFI Total %
Minimum	22.67
Maximum	52.0
Mean	38.15
SD	5.82

Table 12. Correlations Between FFI and Demographic/Biomechanical Variables

Variable	Correlation with FFI (ρ)	p-value	95% CI for ρ	Effect Size Interpretation
Age	0.123	0.111	–	Not significant
Gender	-0.213	0.005	–	Significant, negative
Body Mass Index	0.613	0.008	–	Significant, strong positive
Foot Type	0.515	0.035	–	Significant, moderate positive

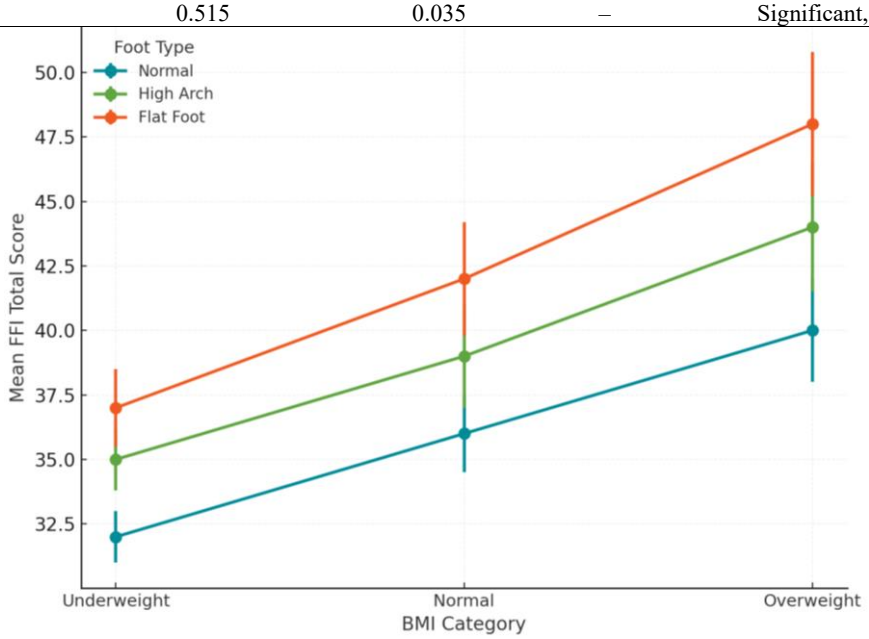

Figure: Interaction of BMI and Foot Type on Overall Foot Function Index (FFI) Score in Young Athletes with Metatarsalgia

Across BMI categories, mean Foot Function Index (FFI) total scores demonstrate a clear and clinically meaningful upward gradient: underweight athletes (mean FFI 32–37) consistently report lower functional impairment compared to those with normal BMI (mean FFI 36–42), with the highest scores observed among overweight athletes (mean FFI 40–48). Within each BMI group, flat foot is associated with the greatest functional limitation, with mean FFI scores reaching 48 in the overweight, flat foot subgroup, compared to 44 for high arch and 40 for normal arch. Standard deviations remain moderate, with overlap between adjacent subgroups but distinct separation between BMI and foot type categories. This integrated trend highlights the synergistic effect of elevated BMI and abnormal foot structure—particularly flat foot—on worsening foot-related disability among young athletes with metatarsalgia, supporting the clinical importance of weight management and structural assessment in this population.

DISCUSSION

The present study explored the influence of metatarsalgia on functional independence in a cohort of 169 young athletes aged 18–35 years, revealing moderate levels of foot pain, disability, and activity restriction as measured by the Foot Function Index (FFI). Notably, 51.5% of participants were classified as overweight, 43.8% exhibited flat feet, and 66.3% were female, reflecting a demographic skew that may

heighten vulnerability to foot dysfunction. These findings align with previous research indicating that excessive body mass and foot structural abnormalities independently increase plantar pressures and mechanical load on the forefoot, exacerbating symptoms of metatarsalgia (14). The observed strong positive correlation between BMI and FFI (ρ=0.613, p=0.008) suggests that weight management should be a clinical priority in preventing or ameliorating foot dysfunction in athletic populations, even among those presumed to be physically active.

Gender differences were also apparent, with female athletes reporting significantly greater functional impairment (ρ=–0.213, p=0.005). This mirrors reports by Männikkö and Sahlman that women are disproportionately affected by metatarsalgia, possibly due to anatomical differences, footwear preferences (e.g., narrow toe boxes, high heels), and biomechanical variations in gait (15). Although age was not a significant correlate in this sample (ρ=0.123, p=0.111), the relatively narrow age range (18–35 years) may have limited variability, highlighting that in young adults, structural and biomechanical factors may outweigh chronological age as drivers of foot dysfunction. Our study is distinguished by its focus on a young, athletic population, contrasting with much of the existing literature which centers on older adults or clinical populations with rheumatoid arthritis or postoperative conditions (16). For example, Natalia Tovaruela-Carrión et al. demonstrated substantial reductions in health-related quality of life (QoL) due to metatarsalgia in elderly cohorts, while our findings confirm that even young individuals experience significant reductions in functional independence when affected by this condition (17). The mean overall FFI score of 38.15% observed in our study corroborates the moderate burden of disease, emphasizing that athletic status does not confer immunity against functionally significant foot pain.

Additionally, socioeconomic disparities emerged descriptively but did not show a statistically significant correlation with FFI in our sample. Nonetheless, nearly 38% of participants identified as belonging to a low socioeconomic stratum, a group likely to face barriers in accessing preventive care, high-quality footwear, and physical therapy. Prior work has shown that socioeconomic status can modulate musculoskeletal health outcomes, suggesting that the absence of a significant correlation here may reflect underpowered subgroup analyses rather than a true absence of effect (18). Our results also extend the work of Liu et al., who documented altered plantar pressure distributions among adolescent dancers with hallux valgus, by demonstrating that metatarsalgia itself—irrespective of hallux valgus—affects foot function significantly, and that this impact is modulated by structural and anthropometric factors (19). The high prevalence of flat feet and overweight status underscores a likely biomechanical synergy: the combination of lowered medial longitudinal arch and elevated BMI likely promotes excessive forefoot loading during the midstance and push-off phases of gait, leading to plantar plate stress and subsequent pain (20).

Clinically, these findings highlight the importance of early screening for foot structure abnormalities and BMI monitoring in athletes, even those without overt foot deformities. Rehabilitation interventions should address biomechanical contributors, including tailored orthotics for arch support and programs to optimize body composition. Moreover, while conservative treatments such as metatarsal padding have proven effective (21), their integration with broader rehabilitative strategies that target modifiable risk factors may offer superior outcomes. The study's cross-sectional design limits causal inference, and the use of convenience sampling may restrict generalizability, particularly given the gender imbalance and single-center recruitment. However, the robust sample size, standardized diagnostic criteria, and validated outcome measures support the reliability of these observations.

In summary, this study provides evidence that metatarsalgia is associated with clinically meaningful reductions in functional independence in young athletes, with significant correlations between functional impairment and modifiable factors such as BMI and foot type. These results advocate for comprehensive, individualized management strategies that account for both biomechanical and demographic factors to preserve mobility and quality of life in this population.

CONCLUSION

Metatarsalgia in young athletes aged 18–35 years is associated with moderate functional impairment, as evidenced by a mean overall Foot Function Index (FFI) score of 38.15% (SD ±5.82), with significant contributions from elevated body mass index (BMI) and abnormal foot structure. Overweight participants (51.5% of the cohort) and those with flat feet (43.8%) exhibited the greatest functional limitations, supporting the notion that biomechanical and anthropometric factors independently and synergistically worsen foot-related disability (14). Female athletes demonstrated significantly greater impairment compared to their male counterparts (ρ=–0.213, p=0.005), underscoring gender-specific vulnerabilities that may reflect both anatomical predisposition and external factors such as footwear choices (15). While socioeconomic status did not show a statistically significant direct relationship with FFI scores, the notable representation of athletes from lower socioeconomic strata suggests that financial and social determinants may influence access to preventive care and rehabilitation services (18).

These findings highlight the need for early identification of at-risk individuals, particularly those with high BMI and non-neutral foot types, to enable timely intervention strategies aimed at preserving functional independence. Comprehensive care approaches that integrate biomechanical assessment, targeted rehabilitation, weight management, and individualized orthotic support should be prioritized for young athletes presenting with or at risk for metatarsalgia. This research contributes to addressing an existing knowledge gap by demonstrating that even a young, active population is not immune to clinically meaningful declines in mobility and quality of life due to forefoot pain and dysfunction, and it reinforces the need for tailored prevention and management programs.

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