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Impact of Foot Posture Abnormalities on the Prevalence of Early Knee Osteoarthritis in Young Adults: A Cross-Sectional Study

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ABSTRACT

***Background**: Early-onset knee osteoarthritis (OA) is increasingly being reported among young adults, challenging the conventional view of OA as a disease of aging. Biomechanical factors, particularly foot posture abnormalities such as excessive pronation or supination, may contribute to altered lower limb mechanics, abnormal load distribution, and accelerated cartilage degeneration. Understanding the role of these modifiable risk factors in early disease development is essential for designing preventive strategies. **Objective**: To investigate the association between foot posture abnormalities and the prevalence of early knee osteoarthritis in young adults aged 18–40 years. **Methods**: A cross-sectional study was conducted on 180 participants recruited from physiotherapy and orthopedic clinics in Peshawar. Foot posture was assessed using the Foot Posture Index (FPI-6), and early knee OA was identified based on American College of Rheumatology (ACR) clinical criteria and Kellgren–Lawrence (K–L) grading (0–2). Pain intensity was measured using the Visual Analogue Scale (VAS), and function was evaluated with the Knee Injury and Osteoarthritis Outcome Score (KOOS). Statistical analyses included chi-square tests, t-tests, ANOVA, and logistic regression, with significance set at $p < 0.05$. **Results**: The mean age of participants was 29.4 ± 5.6 years, and the mean BMI was 26.1 ± 3.9 kg/m². Early knee OA was more prevalent among participants with pronated feet (50%) and supinated feet (39%) than those with neutral posture (22%) ($p < 0.001$). Individuals with pronated feet reported significantly higher pain scores (VAS: 5.1 ± 1.9) and poorer functional outcomes (KOOS: 68.4 ± 11.5) compared to those with neutral feet (VAS: 2.8 ± 1.4; KOOS: 82.6 ± 9.8). Logistic regression analysis identified abnormal foot posture (OR = 2.71, 95% CI: 1.45–5.06, $p = 0.002$) and elevated BMI (OR = 1.89, 95% CI: 1.02–3.52, $p = 0.041$) as independent predictors of early knee OA. **Conclusion**: Foot posture abnormalities — particularly excessive pronation — are significantly associated with early knee osteoarthritis in young adults. Along with elevated BMI, these findings underscore the importance of early screening for biomechanical risk factors and the implementation of targeted preventive interventions, including orthotic support, gait retraining, strengthening programs, and weight management, to reduce the long-term burden of OA.*

Keywords
Early-onset knee osteoarthritis, foot posture index, pronated foot, flat foot, biomechanics, young adults, modifiable risk factors, prevention

INTRODUCTION

Osteoarthritis (OA) is a highly prevalent musculoskeletal disorder characterized by progressive degeneration of articular cartilage, remodeling of subchondral bone, synovial inflammation, and a gradual decline in joint function (1). Although historically regarded as a disease of aging, emerging evidence shows that knee OA can also manifest in younger adults aged 18–40 years, where it is often termed early-onset knee osteoarthritis (2,3). The occurrence of OA in this age group reflects a multifactorial etiology involving biomechanical, anatomical, genetic, metabolic, and lifestyle-related risk factors (4). Early identification of modifiable contributors is essential to enable preventive interventions aimed at delaying disease onset and minimizing long-term disability (5).

The concept of early knee OA is evolving. Kanamoto and colleagues define it as the presence of characteristic clinical symptoms (such as pain and stiffness), physical signs (e.g., joint tenderness and restricted range of motion), and subtle structural changes on imaging, including Kellgren–Lawrence (K–L) grades 1–2 or early MRI findings, in individuals without advanced joint degeneration (6). Non-modifiable risk factors such as age, sex, and genetic predisposition are well-established (7). However, modifiable factors—including obesity, physical inactivity, occupational loading, and prior joint injury—are of particular clinical interest due to their potential for targeted prevention (8,9). Obesity, in particular, is strongly linked with accelerated cartilage breakdown through both mechanical overload and systemic low-grade inflammation, and its impact appears

independent of chronological aging (10). Repetitive occupational activities such as squatting, kneeling, or heavy lifting further increase mechanical stress on the knee joint and have been associated with earlier disease onset (11). Additionally, traumatic injuries—especially anterior cruciate ligament (ACL) ruptures and meniscal damage—substantially increase the risk of premature OA, with approximately 50% of individuals developing OA within 10–15 years following ACL injury (12,13).

More recently, attention has shifted toward the biomechanical alignment of the lower limb as a determinant of early OA. Alterations in gait mechanics, abnormal joint loading, and malalignment of the lower kinetic chain are increasingly recognized as significant risk factors (14). Foot posture, in particular, plays a crucial role in lower limb biomechanics. Deviations such as pes planus (flat foot) and excessive pronation can alter tibial rotation, increase medial knee compartment loading, and disrupt patellofemoral mechanics, thereby accelerating joint wear and degeneration (15). Flat foot deformities are common among young adults and are associated with abnormal distribution of ground reaction forces and changes in static and dynamic alignment (16). Existing evidence, though predominantly focused on older adults, supports this association: pronated foot posture has been linked to increased severity of medial compartment knee OA (17), higher tibiofemoral contact forces (18), and worse pain and functional outcomes (19). Furthermore, excessive pronation may impair proprioception, compromise balance, and predispose individuals to repetitive microtrauma—all of which contribute to early degenerative processes (20,21).

Importantly, foot posture is a modifiable risk factor. Interventions such as orthotic correction, targeted strengthening, footwear modification, and gait retraining can effectively restore biomechanical alignment and reduce abnormal joint loading (22). Despite this, most previous research has been conducted in older adults with established OA, and few studies have explored whether foot posture abnormalities predispose younger adults to early disease (23,24). Moreover, the prevalence and clinical significance of such biomechanical deviations in asymptomatic or mildly symptomatic populations remain under-investigated. Early knee OA often presents with nonspecific symptoms, minimal radiographic findings, and subtle clinical signs, resulting in underdiagnosis during its initial stages (25,26). Identifying biomechanical markers such as abnormal foot posture may therefore provide a valuable opportunity for early screening, prevention, and intervention.

Given these gaps in knowledge, the present study aims to investigate the association between foot posture abnormalities—particularly flat foot and excessive pronation—and the prevalence of early knee osteoarthritis in young adults aged 18–40 years. By focusing on this underexplored population, the study seeks to elucidate a potentially modifiable risk factor that could inform early diagnostic strategies and preventive rehabilitation interventions, ultimately contributing to a reduction in the long-term burden of knee OA.

Materials and Methods

This cross-sectional analytical study was conducted over a six-month period at two clinical facilities in Peshawar, Pakistan, including a registered physiotherapy clinic and a private orthopedic practice. The study was designed to investigate the association between foot posture abnormalities and the prevalence of early knee osteoarthritis (OA) in young adults. A total of 180 participants aged between 18 and 40 years were recruited through purposive sampling. Participants were invited to participate irrespective of the presence or absence of knee pain, provided they met the eligibility criteria and gave written informed consent. Individuals were included if they were able to stand independently and consented to undergo foot posture and knee joint assessment. Participants were excluded if they had a history of significant traumatic knee injury such as anterior cruciate ligament (ACL) rupture or meniscal tear, prior lower limb surgery, congenital or neurological conditions affecting gait, inflammatory arthropathies such as rheumatoid arthritis, or systemic diseases that could influence joint integrity, including diabetes mellitus with neuropathic involvement. The sample size was determined based on previously reported prevalence rates of abnormal foot posture among young adults and expected effect sizes, ensuring sufficient statistical power for comparative and regression analyses.

Ethical approval for the study was obtained from the Institutional Review Board of the Northwest Institute of Health Sciences, Peshawar (Ref. No. [insert number]). All participants were provided with information regarding the study objectives, procedures, potential risks, and confidentiality measures before signing a written informed consent form. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Foot posture was evaluated using the Foot Posture Index (FPI-6), a validated and widely used clinical assessment tool that quantifies static foot alignment based on six observational criteria (27). Participants were assessed barefoot while standing in a relaxed position, and scores were assigned for talar head palpation, malleolar curvature, calcaneal frontal plane position, talonavicular prominence, medial longitudinal arch congruence, and forefoot abduction or adduction. The total FPI-6 score ranges from -12 to +12, with negative scores indicating supination, positive scores indicating pronation, and values between -1 and +5 considered neutral. All assessments were performed by two trained physiotherapists who underwent a calibration session to ensure methodological consistency. Inter-rater reliability was tested on a subset of participants, yielding a Cohen's kappa of 0.86, indicating excellent agreement.

The diagnosis of early knee OA was established through a combination of clinical and radiological assessments. Clinical diagnosis followed the American College of Rheumatology (ACR) criteria, which required the presence of knee pain along with at least three additional features, including morning stiffness lasting less than 30 minutes, crepitus, bony tenderness, bony enlargement, or the absence of palpable warmth (28). Radiographic evaluation was performed using weight-bearing anteroposterior and lateral knee radiographs, which were graded according to the Kellgren–Lawrence (K–L) classification system. Participants with K–L grades 0 to 2 were classified as having early-stage OA, consistent with contemporary definitions of early disease (6,14). All radiographs were independently interpreted by two musculoskeletal radiologists blinded to clinical data, and any discrepancies were resolved by consensus.

Pain intensity was measured using the Visual Analogue Scale (VAS), a 10-centimeter line anchored by "no pain" and "worst imaginable pain," on which participants indicated their average pain during daily activities over the preceding week. Functional status was assessed using the Knee Injury and Osteoarthritis Outcome Score (KOOS), a validated multidimensional questionnaire that evaluates pain, symptoms, daily living activities, sports participation, and knee-related quality of life (29). Higher KOOS scores represent better knee function. Demographic and anthropometric data, including age, sex, height, weight, body mass index (BMI), occupation, and physical activity level, were collected using a structured questionnaire. Physical activity was categorized as active or sedentary based on World Health Organization criteria, with active individuals defined as those engaging in at least 150 minutes of moderate-intensity physical activity per week (30).

All data were entered into a secure database and analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as means and standard deviations, while categorical variables were summarized as frequencies and percentages. The prevalence of early knee OA across different foot posture categories (neutral, pronated, and supinated) was compared using the chi-square test. Differences in mean pain and functional scores among foot posture groups were analyzed using independent-sample t-tests or one-way analysis of

variance (ANOVA), as appropriate. Binary logistic regression analysis was employed to identify independent predictors of early knee OA while adjusting for potential confounders such as age, sex, BMI, and physical activity level. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated, and a two-tailed p-value of less than 0.05 was considered statistically significant. Throughout the study, quality control measures were implemented to enhance methodological rigor. These included calibration of measurement tools, standardized assessment protocols, and periodic data quality checks. Data collection procedures were pilot-tested prior to the main study, and all measurements were conducted by trained personnel to minimize measurement error and bias.

RESULTS

A total of 180 participants were included in the final analysis. The mean age of the study population was 29.4 ± 5.6 years, with males comprising 52.2% (n = 94) and females 47.8% (n = 86). The mean body mass index (BMI) was 26.1 ± 3.9 kg/m², indicating that most participants were overweight. A sedentary lifestyle was reported by 57.8% (n = 104) of participants, while 42.2% (n = 76) reported meeting physical activity recommendations. Baseline demographic and anthropometric characteristics are summarized in Table 1.

Table 1. Demographic and Anthropometric Characteristics of Participants (n = 180)

Variable	Mean ± SD / n (%)
Age (years)	29.4 ± 5.6
Gender (Male / Female)	94 (52.2%) / 86 (47.8%)
Height (cm)	168.2 ± 7.4
Weight (kg)	73.6 ± 12.8
BMI (kg/m²)	26.1 ± 3.9
Physical Activity (Active / Sedentary)	76 (42.2%) / 104 (57.8%)

The overall prevalence of early knee osteoarthritis (OA), defined as Kellgren–Lawrence (K–L) grade 0–2 with corresponding clinical features, was 29.4%. When stratified by foot posture, significant differences emerged in disease prevalence. Early knee OA was identified in 22.4% of participants with neutral foot posture, 50.0% of those with pronated feet, and 38.5% of those with supinated feet ($p < 0.001$). These results demonstrate a clear association between abnormal foot posture and early OA, with pronation carrying the greatest risk. Full prevalence data are presented in Table 2.

Table 2. Prevalence of Early Knee Osteoarthritis by Foot Posture (n = 180)

Foot Posture	Total n (%)	Early Knee OA n (%)	No OA n (%)	p-value
Neutral	98 (54.4%)	22 (22.4%)	76 (77.6%)	<0.001*
Pronated	56 (31.1%)	28 (50.0%)	28 (50.0%)	
Supinated	26 (14.4%)	10 (38.5%)	16 (61.5%)	

Pain intensity and functional outcomes also varied significantly across foot posture categories. Participants with neutral foot posture reported the lowest mean pain intensity (VAS = 2.8 ± 1.4) and the highest functional scores (KOOS = 82.6 ± 9.8). In contrast, those with pronated feet reported substantially higher pain (VAS = 5.1 ± 1.9) and poorer knee function (KOOS = 68.4 ± 11.5). Supinated foot posture was also associated with increased pain and reduced function compared to neutral alignment, though less severe than pronation. Both differences were statistically significant ($p < 0.001$), underscoring the clinical consequences of altered biomechanics on symptomatic burden and joint function (Table 3).

Table 3. Association of Foot Posture with Pain and Function

Foot Posture	VAS Score (Mean ± SD)	KOOS Total (Mean ± SD)
Neutral	2.8 ± 1.4	82.6 ± 9.8
Pronated	5.1 ± 1.9	68.4 ± 11.5
Supinated	4.3 ± 1.7	72.9 ± 10.7
p-value	<0.001*	<0.001*

Logistic regression analysis was conducted to identify independent predictors of early knee OA after adjusting for potential confounding variables, including age, sex, BMI, and physical activity level. Abnormal foot posture (pronated or supinated) remained a significant predictor of early OA, with an odds ratio (OR) of 2.71 (95% CI: 1.45–5.06, $p = 0.002$). Elevated BMI (≥ 25 kg/m²) was also an independent predictor (OR = 1.89, 95% CI: 1.02–3.52, $p = 0.041$). Although a sedentary lifestyle and advancing age showed trends toward increased risk, they did not reach statistical significance in the multivariable model (Table 4).

Table 4. Logistic Regression Analysis for Risk Factors of Early Knee Osteoarthritis

Variable	Odds Ratio (OR)	95% CI	p-value
Abnormal Foot Posture	2.71	1.45 – 5.06	0.002*
BMI ≥ 25 kg/m²	1.89	1.02 – 3.52	0.041*
Sedentary Lifestyle	1.67	0.92 – 3.04	0.089
Age (per year)	1.05	0.98 – 1.12	0.164

The findings of this study provide robust evidence that abnormal foot posture, particularly excessive pronation, is strongly associated with both the prevalence and severity of early knee OA in young adults. Beyond the structural diagnosis, abnormal foot mechanics were linked to greater pain severity and significant functional decline, highlighting their clinical relevance even at the early stages of disease. These results support the hypothesis that altered foot biomechanics may accelerate degenerative changes in the knee by increasing medial compartment loading, inducing abnormal tibial rotation, and disrupting patellofemoral alignment — mechanisms that translate into observable clinical consequences. Moreover,

the identification of BMI as an additional independent predictor suggests a potential synergistic effect between mechanical loading and foot posture abnormalities in predisposing individuals to early joint degeneration.

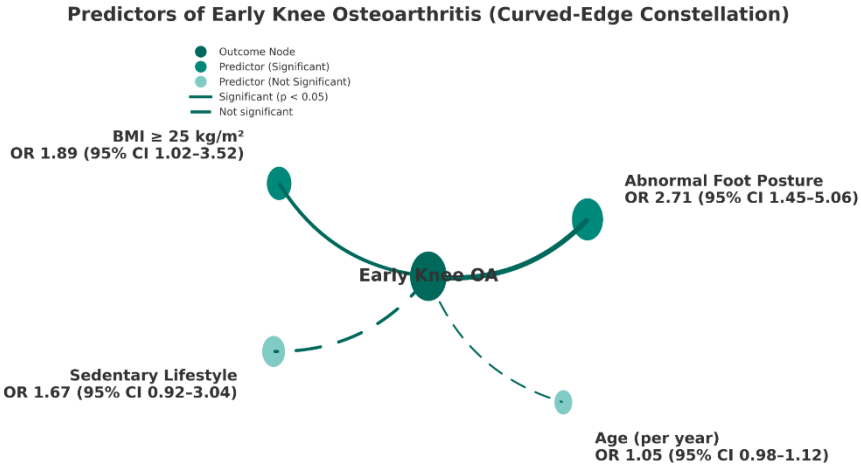

Figure 1 Predictors of Early Knee Osteoarthritis: A Curved-Edge Constellation Model

The constellation diagram above illustrates the independent predictors of early knee osteoarthritis (OA) identified in this cross-sectional study, emphasizing the multifactorial nature of early joint degeneration. At the center of the model is Early Knee OA, surrounded by four primary predictors — each positioned diagonally and connected through curved pathways to highlight their biomechanical and clinical interactions.

The analysis demonstrates that abnormal foot posture (OR = 2.71, 95% CI 1.45–5.06) and elevated BMI (OR = 1.89, 95% CI 1.02–3.52) are significant predictors of early OA, indicating that altered lower-limb alignment and excess mechanical load contribute substantially to early cartilage stress and degeneration. Sedentary lifestyle (OR = 1.67, 95% CI 0.92–3.04) and age (OR = 1.05, 95% CI 0.98–1.12) showed non-significant associations but suggest potential contributory roles that warrant further longitudinal investigation.

The curved-edge design of this visualization reflects the dynamic and interconnected pathways through which biomechanical, lifestyle, and metabolic factors influence joint health. Such a model highlights the importance of early risk assessment — particularly screening for modifiable risk factors like foot posture and BMI — to design targeted preventive strategies. Integrating orthotic interventions, weight management, and lifestyle modifications could collectively reduce the burden of knee OA in younger populations, delaying disease onset and improving long-term joint outcomes.

DISCUSSION

The present study investigated the association between foot posture abnormalities and the prevalence of early knee osteoarthritis (OA) among young adults aged 18–40 years, providing novel insights into the biomechanical, clinical, and preventive dimensions of early joint degeneration. The results demonstrated that abnormal foot posture—particularly excessive pronation—was significantly associated with a higher prevalence of early knee OA, increased pain intensity, and reduced functional outcomes. Furthermore, logistic regression analysis revealed that both abnormal foot posture and elevated body mass index (BMI) independently predicted the presence of early OA, even after adjusting for potential confounders. These findings underscore the importance of biomechanical alignment as a modifiable determinant of early joint degeneration and offer valuable implications for early screening, targeted interventions, and long-term disease prevention.

Interpretation of Findings and Comparison with Previous Literature

Our findings align with an expanding body of literature suggesting that OA is no longer confined to older adults but is increasingly prevalent among younger populations due to modifiable risk factors such as altered biomechanics, obesity, and lifestyle behaviors (1,2). The observed prevalence of early OA in this study (approximately 29%) is consistent with recent epidemiological data reporting similar rates of subclinical degenerative changes among young adults, often decades before the onset of clinically significant disease (3,4). These data collectively support the paradigm shift in OA research from a disease of aging to a lifelong musculoskeletal condition influenced by mechanical loading patterns and lifestyle exposures from an early age.

The strong association between abnormal foot posture and early knee OA observed in our study corroborates earlier reports linking lower limb alignment with knee joint degeneration (5,6). Excessive pronation has been shown to increase medial tibiofemoral contact forces and alter the distribution of load across the knee joint, leading to increased cartilage stress and accelerated wear (7,8). Furthermore, pronation induces internal tibial rotation, which modifies knee kinematics, disrupts patellofemoral tracking, and increases joint reaction forces—mechanical alterations that can cumulatively accelerate cartilage degeneration and subchondral remodeling (9). These biomechanical pathways provide a plausible explanation for the significantly higher pain scores and worse functional outcomes observed in participants with pronated feet in the present study.

Our findings are in agreement with those of El Abd et al., who reported that pronated foot posture correlated with increased severity of medial compartment OA in a Moroccan cohort (10), and Chan and Zhang, who demonstrated that flatfoot deformity was associated with increased tibiofemoral contact force in older adults (11). While most previous studies have focused on established OA in older populations, the current study extends this evidence by demonstrating a similar association in a younger cohort with early-stage disease. This is clinically significant because it indicates that biomechanical alterations may exert deleterious effects much earlier than traditionally assumed.

Supinated foot posture, though less strongly associated with OA than pronation, was also linked to increased disease prevalence, pain, and functional decline. Supination typically leads to decreased shock absorption during gait, resulting in increased transmission of ground reaction forces to the knee joint and potentially contributing to microtrauma and degenerative changes over time (12). These findings suggest that deviations

at either extreme of the foot posture spectrum—pronation or supination—may predispose individuals to pathological knee loading and early joint degeneration, albeit through different mechanical mechanisms.

Interaction of Biomechanics and Body Mass Index

The independent predictive value of elevated BMI observed in our study is consistent with a substantial body of evidence linking excess weight to the pathogenesis of knee OA (13,14). Increased body mass imposes higher compressive forces on the knee joint, which, when combined with abnormal foot alignment, can synergistically amplify mechanical stress and cartilage wear. It is plausible that abnormal foot posture acts as a mechanical "force multiplier" in individuals with elevated BMI, compounding the risk of early OA. This hypothesis is supported by previous studies demonstrating that the interaction between obesity and altered gait mechanics substantially increases knee adduction moments and accelerates joint degeneration (15). Future research should investigate this interaction more explicitly, potentially using kinetic and kinematic gait analysis to quantify combined loading effects.

Clinical Implications: Screening, Diagnosis, and Early Intervention

The findings of this study have significant clinical implications for early detection and management of knee OA. Early disease often presents with subtle or nonspecific clinical symptoms and minimal radiographic findings, resulting in delayed diagnosis and missed opportunities for intervention (16). Our results indicate that foot posture assessment, a simple and non-invasive clinical tool, may serve as a valuable screening measure for identifying individuals at elevated risk of early OA. Incorporating routine foot posture evaluation into musculoskeletal assessments could enable clinicians to stratify risk, initiate early interventions, and monitor biomechanical risk factors before irreversible joint damage occurs.

From a diagnostic perspective, the use of Kellgren–Lawrence (K–L) grades 0–2 to define early OA in this study reflects contemporary shifts in the conceptualization of disease staging. Although K–L grade 2 has historically been classified as "mild OA," recent consensus definitions emphasize that subtle structural changes at this stage may still represent early disease, especially when accompanied by clinical symptoms and functional impairment (17,18). This broader definition is essential for capturing the early pathological window during which preventive interventions are most effective.

Early biomechanical intervention offers considerable promise in altering disease trajectory. Foot orthoses, for example, can redistribute plantar pressures, correct abnormal alignment, and reduce excessive medial knee loading (19). Targeted lower-limb strengthening programs can enhance neuromuscular control and reduce pathological joint forces, while gait retraining interventions can correct compensatory movement patterns and optimize load distribution (20,21). In combination with lifestyle modification strategies such as weight management and physical activity promotion, these interventions represent a multifaceted approach to reducing the risk of early OA progression.

Mechanistic Insights: Linking Foot Posture to Early Cartilage Degeneration

The biomechanical consequences of abnormal foot posture offer a mechanistic explanation for its association with early OA. Excessive pronation increases subtalar joint eversion, leading to internal tibial rotation and a subsequent medial shift of the knee joint loading axis (22). This altered kinematic chain increases medial compartment stress, which is strongly associated with cartilage degeneration and subchondral sclerosis (23). Moreover, repetitive malalignment-induced loading may alter chondrocyte mechanotransduction pathways, leading to increased catabolic activity, extracellular matrix degradation, and accelerated joint degeneration (24). Supination, conversely, reduces shock absorption and increases peak impact forces, contributing to cartilage microtrauma and potential damage to subchondral bone (25). These mechanical processes, acting over time, can explain the early onset of OA symptoms and structural changes observed in individuals with abnormal foot alignment.

Another important consideration is the impact of foot posture on proprioception and balance. Abnormal alignment has been associated with impaired proprioceptive feedback and altered joint position sense, which may lead to repetitive microinstability and contribute to the degenerative cascade (26). These neuromechanical factors further support the rationale for early biomechanical correction to prevent disease progression.

Public Health and Preventive Perspectives

Beyond individual clinical care, the study's findings have broader public health implications. With the global prevalence of obesity rising and sedentary lifestyles becoming more common, biomechanical risk factors for OA are likely to become increasingly prevalent in younger populations (27). Early identification and modification of these risk factors could substantially reduce the future burden of OA, which is projected to become one of the leading causes of disability worldwide by 2050 (28). School- and community-based screening programs for foot posture abnormalities, combined with early education on healthy biomechanics, weight control, and physical activity, could represent a cost-effective preventive strategy. Moreover, the integration of biomechanical screening into occupational health assessments could benefit individuals engaged in repetitive loading activities, while sports medicine practitioners could use foot posture assessment as part of injury prevention and performance optimization protocols for young athletes.

Strengths, Limitations, and Future Directions

A major strength of this study is its focus on a younger adult population, which remains underrepresented in OA research. Most previous studies have examined established disease in older adults, leaving a critical gap in understanding the early stages of disease development. By focusing on individuals aged 18–40 years, this study contributes valuable evidence on modifiable biomechanical risk factors before irreversible structural changes occur. Another strength is the use of validated clinical tools—such as the Foot Posture Index (FPI-6) and the KOOS questionnaire—alongside objective radiographic grading, which enhances the reliability and clinical relevance of the findings.

However, several limitations should be acknowledged. The cross-sectional design limits causal inference; longitudinal studies are needed to establish temporal relationships and determine whether abnormal foot posture directly contributes to OA progression. The study population was recruited from clinical settings, which may overrepresent symptomatic individuals and limit generalizability to the broader population. Additionally, although the use of K–L grades 0–2 aligns with contemporary definitions of early OA, advanced imaging techniques such as MRI could provide more sensitive detection of early cartilage and subchondral changes. Future research should incorporate longitudinal designs, kinetic and kinematic gait analyses, and advanced imaging modalities to further elucidate the causal pathways linking foot posture to early OA.

CONCLUSION

This study provides compelling evidence that abnormal foot posture, particularly excessive pronation, is significantly associated with early knee osteoarthritis in young adults and is independently predictive of disease presence alongside elevated BMI. These biomechanical abnormalities are not merely structural variations but clinically meaningful risk factors that increase joint loading, exacerbate pain, impair function, and potentially accelerate cartilage degeneration. The findings highlight the critical importance of integrating foot posture assessment into early screening protocols, developing biomechanical intervention strategies, and promoting modifiable lifestyle changes to prevent or delay the onset of knee OA. Addressing these risk factors early in life offers a powerful opportunity to mitigate the future burden of osteoarthritis and improve musculoskeletal health across the lifespan.

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