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Original Research Article

The influence of age and BMI on foot progression angle in knee osteoarthritis: a correlation analysis

Aavrati Rastogi, Roop B. Kalia*, Pradeep K. Meena

Department of Orthopedics, AIIMS Rishikesh, Uttarakhand, India

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***Correspondence:**
Dr. Roop B. Kalia,
E-mail: roop.orth@aiimsrishikesh.edu.in

ABSTRACT

Background: Knee osteoarthritis (KOA) is a degenerative joint disease, often associated with age and body mass index (BMI), critical demographic factors influencing its progression. The Foot Progression Angle (FPA), a measure of foot alignment, has been studied as a potential contributor to the development and progression of KOA.
Methods: A comprehensive prospective analysis investigated the relationship between age, BMI, and FPA in individuals diagnosed with KOA. The study included data from participants categorized based on their Kellgren-Lawrence (K/L) grades: K/L grade II and K/L grade III. Correlation coefficients (R) and p values were meticulously calculated to assess these relationships' strength and statistical significance.
Results: Our correlation analysis in KOA (K/LII and III) showed weak, non-significant correlations between age, BMI, and FPA. Specifically, age was linked with FPA at -0.1415 (p value 0.3499) in K/L 2 and -0.1257 (p value 0.33) in K/L grade 3, while BMI correlations were -0.125 (p value 0.40) in K/L 2 and -0.1402 (p value 0.27) in K/L 3.
Conclusions: While BMI and age are significant factors in KOA, their relationship with FPA is weak and insignificant. This finding paves the way for further research to explore other biomechanical factors that may play a more substantial role in knee OA progression

Keywords: Foot progression angle, Knee adduction moment, Osteoarthritis

INTRODUCTION

The association between age, BMI, and FPA in people with KOA is essential for understanding the biomechanical parameters influencing disease progression and symptomatology. KOA is a common condition that significantly impacts mobility and quality of life, especially among older persons. Age is a well-established risk factor for the development of OA. The prevalence and severity of the illness increase as a person ages due to accumulated mechanical stress on the joints and degenerative changes in cartilage and other joint components.[1] BMI, which is commonly employed as a measure of obesity, has also been connected to KOA progression. Elevated BMI increases the mechanical load on the knee joint, which might worsen cartilage degeneration, especially in people with pre-existing malalignment.[2] According to studies, higher BMI is associated with increased OA severity; however, the relationship is more significant in patients with mild malalignment than in those with neutral or severe malalignment.[3] Biomechanical parameters like FPA could influence the association between BMI and KOA progression.

FPA is the angle at which the foot moves during walking, which influences lower limb kinematics and stress patterns at the knee. Changes in FPA, such as toeing in or out, can majorly impact knee loading mechanics. Modifying FPA has been proven in studies to minimize the external knee adduction moment (EKAM), which is associated with medial compartment loading in patients with KOA. Understanding how age and BMI interact with FPA can help guide tailored gait therapies for knee discomfort and disease progression.[4]

METHODS

Study design

This cross-sectional time-bound study was conducted between September 2023 to August 2024 in the Department of Orthopaedics at AIIMS, Rishikesh.

Patient selection

A total of 108 patients, both men and women, aged 45 to 70 years, with knee osteoarthritis, unilateral or bilateral, grade 2 or 3 on the Kellgren-Lawrence scale were included after taking consent. A structured questionnaire collected information such as age, weight, height, gender, education, occupation, and comorbidities Functional testing was used to classify KOA groups. Radiographic findings were evaluated using the KL grade criteria (0 regular, one possible osteophyte, 2 definite osteophytes, and possible joint space narrowing, 3 moderate and/or multiple osteophytes, definite J and possible bony attrition, 4 large osteophytes, sub-chondral sclerosis, and definite bony attrition). Individuals with a pain intensity score of 1, 2, or 3 on the WOMAC (modified CRD pune version) and a Karnofsky performance score of 80-90% were included in the study based on the inclusion criteria. The exclusion criteria were any assisted device needed for ambulation-patients using prescribed footwear modification, and any intra-articular injection within the last 3 months.

Data collection and evaluation

All the patients underwent gait analysis in GAIT LAB BTS (Smart-DX 6000). Gait analysis was performed under 12 LED infra-red internet protocol base cameras, 4 video cameras, and 10 force plates (8 analog and two digital). Helen Hayes protocol was provided with BTS smart-clinic software, which was used for gait analysis. After anthropometric measurement, 18 surface markers will be placed on the patient according to Helen Hayes protocol. Patients were told to walk at a self-determined speed down a 5-m walkway. At least three walking trials with consistent speed and proper force plate contact were taken to obtain data for subsequent investigation after three to five getting acquainted trials.

Data processing

The kinematic, kinetic, and FPA data were processed through custom software (Smart-DX 6000). The kinematic and kinetic data were processed using digital low pass filters (recursive fourth-order Butterworth) with 8 and 60 Hz frequency cut-offs, respectively. The net external knee adduction moment was calculated using an inverse dynamics model that used GRF and moment data, kinematic positional data specified using the techniques outlined in Grood and Suntay, limb anthropometrics, and inertial properties. The knee adduction moment waveform was shown as a normalized net external moment (N m/kg) with 101 data points or one complete gait cycle (0-100%). This demonstrates the time-normalized knee adduction moment waveform. The FPA was calculated using the foot vector (from the second metatarsal to the posterior middle calcaneus) and the lab coordinate representing the line of progression. Compared to known angles marked on the walkway force platform, this technique showed an inaccuracy of less than 1°.[4]

Data analysis

The most significant value between 30 and 60% of the gait cycle was computed for each participant to indicate the maximum magnitude of the knee adduction moment in N m/kg during late stance. The path of the center of pressure on the plantar surface of the foot, where the GRF vector is assumed to act during gait, was determined using force plate data. The long axis of the foot was created by linking the centers of pressure at heel strike and toe-off. The toe-out angle for each leg was determined by calculating the angle produced by the foot's long axis and the forward motion's direction.[4,5]

Statistical analysis

Age and body mass index (BMI) followed a normal distribution, but the remaining factors did not. Descriptive statistics included frequency tables. The mean and standard deviation were used for regularly distributed data, whereas non-normally distributed data was represented by the median and interquartile range. The t test was used to compare means between two groups in normally distributed data. P values less than or equal to 0.05 were considered significant. The statistical calculations were done with the SPSS version 21 software program.

RESULTS

The study included 108 patients, 68 females and 40 males, all with knee osteoarthritis. Table 1 shows that the patients had a mean age of 55.92±0.8 years and a mean BMI of 27.24±0.4 kg/m^2. The correlation of age, BMI, and FPA in KOA patients across K/L grades II and III revealed weak negative connections. In K/L grade II, the correlation between age and FPA was -0.14, while in K/L grade III, it was -0.12. Both correlations were not statistically significant (p values of 0.34 and 0.33, respectively). The association between BMI and FPA in K/L grade 2 was -0.12; in K/L grade 3, it was -0.14, but neither was statistically significant (p=0.40 and p=0.27), shown in Table 2. These results suggest that age and BMI do not have a notable impact on FPA in KOA patients, emphasizing the need to explore other factors, such as joint biomechanics and muscle strength, which could influence foot progression more significantly.

Table 1: Demographic details.

	Mean±SD	P value
Age	55.92±0.8	<0.05
BMI	27.24±0.4	0.20
Gender	n=108	Percentage
Male	40	44
Female	68	62

Table 2: Correlation analysis between age, BMI, and FPA.

Foot progression angle		
Age	**KL grade II**	**KL grade III**
R	-0.14	-0.12
p value	0.34	0.33
BMI		
R	-0.12	-0.14
p value	0.40	0.27

DISCUSSION

The findings suggest that neither age nor BMI has a statistically significant relationship with the FPA in persons with KOA across the K/L grades studied. While minor negative associations were found, the lack of statistical significance indicates that these demographic characteristics have no strong or consistent influence on FPA.[6]

Several explanations could explain these results. Age and BMI are frequently cited as risk factors for KOA, but their connection with FPA may be altered by other biomechanical or clinical factors not included in our research.[7] Furthermore, the small effect size (low R values) indicates that other variables, such as joint mechanics, muscular strength, or alignment aberrations unrelated to demography, may more significantly influence FPA.

Recent research suggests a minimal link between demographic parameters such as age and BMI and the FPA in people with KOA. A study that monitored foot progression angles during real-world walking discovered that FPA variability was significantly higher in unsupervised than controlled laboratory settings.[7-9] However, structural and symptomatic severity did not correlate with FPA in either environment, except for a specific condition associated with moderate-severe structural OA.[10,11] This implies that whereas age and BMI are frequently identified as risk factors for KOA, their influence on FPA may be surpassed by other biomechanical factors, such as joint mechanics and muscle strength.

This study has few limitations. This study's small sample size may have compromised statistical power. The cross-sectional approach precludes the examination of causal relationships. Key biomechanical aspects such as muscle strength, joint alignment, and gait mechanics were not considered, which could alter FPA. External factors, such as footwear, exercise levels, and walking surfaces, were also overlooked. Future research should include bigger sample sizes, longitudinal data, and additional biomechanical characteristics to further understand FPA's function in knee OA progression.

CONCLUSION

While age and BMI play a significant role in KOA, their relationship with FPA appears small and statistically insignificant. Future research should include more significant sample numbers, a broader variety of covariates, and longitudinal data to understand further the role of demographic factors in foot alignment and KOA progression. Understanding these correlations may pave the way for more effective treatment interventions addressing biomechanical misalignments in OA patients.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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