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CORRELATION BETWEEN BODY MASS INDEX (BMI) AND FEMOROTIBIAL JOINT SPACE WIDTH ON LYON-SCHUSS KNEE RADIOGRAPHS IN PATIENTS WITH KNEE OSTEOARTHRITIS AT H. ADAM MALIK GENERAL HOSPITAL, MEDAN, IN 2025

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Abstract

Background: Knee osteoarthritis (OA) is the most common form of osteoarthritis and a frequent cause of chronic health problems. The femorotibial joint space is one of the most predictive factors associated with clinical symptoms and outcomes in patients with knee OA. Obesity is a major risk factor for the development of knee OA. Measurement of the knee joint space is most accurately performed using the Lyon-Schuss position. **Methods:** This study is an analytic study with a cross-sectional design. Radiological examinations were performed in the *Lyon-Schuss* position, and the narrowest femorotibial joint space was measured. Bivariate analysis using the chi-square test The Mann-Whitney U and Kruskal-Wallis test. Correlation analysis was then performed to determine the strength of the relationship between BMI and femorotibial joint space width. **Results:** Bivariate analysis showed a relationship between BMI and OA grade ($p = 0.093$), as well as between femorotibial joint space width and both BMI ($p = 0.000$) and OA grade ($p = 0.000$). A negative correlation was found between BMI and femorotibial joint space width, with the regression equation: $y = 8.577 - 0.255x$, where y represents femorotibial joint space width (mm) and x represents BMI ($p = 0.000$; $R^2 = 0.306$). **Conclusion:** There is a negative correlation between body mass index and femorotibial joint space width in patients with knee osteoarthritis.

Keywords: ***Knee osteoarthritis, body mass index (BMI), femorotibial joint space width, Lyon-Schuss position.***

INTRODUCTION

Osteoarthritis (OA) is the most prevalent type of arthritis and represents one of the most common chronic health disorders. Among its forms, knee osteoarthritis (OA of the knee) has the highest incidence rate. According to the World Health Organization (2023), approximately 528 million people worldwide were affected by OA in 2019, marking a 113% increase compared to 1990. Obesity, defined as excessive accumulation of visceral fat that impairs health, is a major contributing factor. In 2022, the World Health Organization reported that over 2.5 billion adults aged 18 years and above were overweight, with 200 million women and 300 million men classified as obese—a number projected to continue rising over the next 50 years (World Health Organization, 2024). There is substantial evidence supporting the association between obesity and the development of knee OA. A study by Shumnalieva et al. (2023) identified a negative correlation between body mass index (BMI) and femorotibial joint space width, indicating that an increase in BMI is linked to greater narrowing of the femorotibial joint space.

Radiographic imaging is commonly used as an initial step in evaluating knee OA. Since joint space narrowing is a major clinical feature, the position during imaging plays a critical role in accurately measuring the femorotibial joint space. Mazzuca (2008) found that the Lyon-Schuss position demonstrated the highest sensitivity and reproducibility compared to conventional weight-bearing views. This imaging technique involves aligning the pelvis, patella, and great toe with the film cassette, with the knee flexed at approximately 20°. The X-ray beam is angled parallel to the tibial plateau to ensure that the anterior and posterior aspects do not overlap (Mazzuca, 2008). The development of digital radiography and computer-based measurement software has made it possible for overweight and obese individuals to detect joint space narrowing at an early stage, even in the absence of symptoms (Riskesdas, 2018). Lim et al. (2022) found that weight management is one of the most effective ways to prevent and alleviate symptoms of knee osteoarthritis. Setting specific and measurable weight loss goals can improve patient motivation and adherence to therapy (Riskesdas, 2018). Unfortunately, there are still limited studies in Indonesia—especially in North Sumatra—regarding the quantitative correlation between body mass index (BMI) and femorotibial joint space width in OA patients. In fact, joint space measurement could potentially be used as both a preventive and therapeutic approach for knee OA, allowing clinicians to predict target weight loss for individual patients.

LITERATURE REVIEW

According to the American College of Rheumatology, osteoarthritis (OA) is a group of heterogeneous disorders that result in joint-related signs and symptoms. Knee osteoarthritis (OA genu) arises due to disrupted metabolic homeostasis of the articular cartilage and is marked by proteoglycan degradation, the exact cause of which remains unknown. Several risk factors contribute to OA development, including age, sex, genetics, trauma, physical activity, occupation, and body weight (Kolanski et al., 2020). Overweight and obesity significantly increase the risk of developing OA by adding mechanical stress to the lower extremity joints. Abnormal and excessive mechanical loads disturb cartilage homeostasis and lead to joint deformities, triggering and accelerating the progression of knee OA. Obese individuals also tend to have larger thigh circumferences, which causes increased hip abduction and varus malalignment of the knee during walking in an effort to avoid thigh contact. Furthermore, obesity is associated with relative muscle dysfunction. In obese women with knee OA, a negative correlation has been observed between body weight and the strength of the knee extensors (quadriceps muscles) (Dare, 2020; Shumnalieva, 2022).

However, mechanical factors represent not only part of the underlying mechanisms. Joint overload also raises the levels of IL-1 and TNF, which contribute to extracellular matrix (ECM) degradation in cartilage. Adipose tissue plays a central role, serving as a source of cytokines, chemokines, and bioactive mediators collectively known as adipokines. Additionally, the cellular composition of adipose tissue differs between lean and obese individuals. Obesity is associated with a shift from anti-inflammatory M2 macrophages to classically activated M1 macrophages that release pro-inflammatory cytokines. These complex mechanisms further link obesity to other pathological conditions of metabolic syndrome, such as dyslipidemia and insulin resistance. The width of the knee joint space is one of the best predictors of symptoms and clinical outcomes in patients with OA genu, making accurate measurement essential. In many cases, knee radiographs are taken in full extension, as seen in conventional weight-bearing X-rays. However, this position tilts the tibial plateau away from the horizontal beam angle, causing overlap between the anterior and posterior parts of the tibial plateau and resulting in unclear joint space margins and biased measurements (Sharp, 2005; Hellio, 2009; Buckland, 1999; Bruyere, 2002). The Lyon-Schuss view has been shown to provide good reproducibility and is relatively easy to perform. This technique involves posteroanterior (PA) radiography with the knee under weight-bearing conditions, flexed at 20–30 degrees. It is a modified version of the Rosenberg view, with the main difference being that the X-ray beam is directed parallel to the tibial plateau (Themes, 2021; AP Projection, 2012).

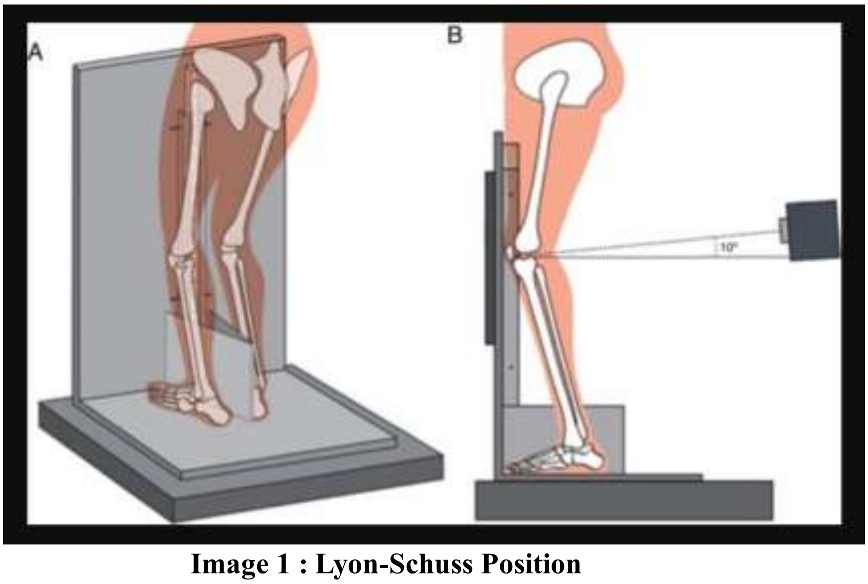

Image 1 : Lyon-Schuss Position

According to Hellio et al. (2009), the narrowest point of the femoro-tibial joint space demonstrates higher reproducibility and greater sensitivity in reflecting the severity of osteoarthritis. Measurements can be made to the nearest 0.1 mm using electronic calipers (Themes, 2021; AP Projection, 2012).

Image 2 : Measurement of the femoro-tibial joint space using the Lyon-Schuss position.

METHOD

This study employed a cross-sectional design using knee X-ray images of patients with knee osteoarthritis (OA genu) at Adam Malik General Hospital, Medan, collected from April to June 2025. All patients diagnosed with OA genu who underwent Lyon-Schuss position knee radiography were included as the study sample. Patients with a history of trauma, surgery, or bone tumors involving the femur, tibia, or patella, as well as those with knee X-rays containing artifacts, were excluded. Following approval from the Ethics Committee of the Faculty of Medicine, Universitas Sumatera Utara, eligible subjects who met the inclusion and exclusion criteria were selected. Their body weight and height were measured, and demographic data such as age, sex, and occupation were recorded. The radiographic images were downloaded in DICOM format and analyzed using the RadiAnt software on an Acer Spin 3 laptop. Joint space width and OA grading were assessed through the RadiAnt application and confirmed by an independent radiologist. The data were analyzed using univariate, bivariate, and correlation tests, following a normality assessment. Univariate analysis was used to describe the frequency distribution. Bivariate analysis was performed to explore the relationship between OA grade and femorotibial joint space width with variables such as age, sex, occupation, and body mass index (BMI). Lastly, a regression analysis was conducted to evaluate the quantitative correlation between BMI and femorotibial joint space width.

RESULT AND DISCUSSION

A total of 50 subjects with knee osteoarthritis (OA genu) were included in this study conducted at Adam Malik General Hospital, Medan. The characteristics of the study sample are summarized in Table 1. The majority of participants were aged ≥40 years (45 subjects, 90%), female (34 subjects, 68%), and worked indoors (40 subjects, 80%).

Table 1. Characteristics of Patients with Knee Osteoarthritis

Characteristics	Frequency
Age,n (%)	
<40	5 (10%)
≥40	45 (90%)
Gender, n (%)	
Man	16 (32%)
Woman	34 (68%)
Occupation, n (%)	
Indoor	40(80%)
Outdoor	10 (20%)

Based on Table 2, which presents Body Mass Index (BMI), joint space width, and osteoarthritis (OA) grade among patients with knee OA at Adam Malik Hospital Medan, the majority of patients were classified as normoweight (24 individuals, 48%). The mean BMI was 24.09 ± 3.46, with a median of 23.44 and a range of 18.41 to 31.1. The mean joint space width was 2.42 ± 1.59 mm, with a median of 2.93 mm and a range from 0.0 to 5.05 mm. In terms of OA severity grading, most patients were classified as Grade II (19 individuals, 38%), followed by Grade I (11 individuals, 22%), and Grades III and IV each comprising 10 individuals (20%). The chi-square test was used to assess the association between OA grade and age, sex, and body mass index (BMI), as both variables were categorical and the sample size consisted of 50 subjects. The results of this analysis are presented in Table 3. Since joint space width is a numerical variable, a normality test was required before selecting the appropriate statistical analysis. Given the sample size of 50, the Shapiro-Wilk test was used. The test yielded a p-value of 0.002 ($p < 0.005$), indicating that the data were not normally distributed. Therefore, bivariate analysis was conducted using the Mann-Whitney U test (for comparisons involving two categories) and the Kruskal-Wallis test (for comparisons involving three or more categories). The results of these tests are displayed in Table 4.

Table 2: Body Mass Index, Joint Space Width, and OA Grade in Patients with Knee Osteoarthritis

Variable	Frequency (%)	Mean ± SD	Median (range)
Body Mass Index (BMI), n (%)			
Normoweight	24(48%)	24,09 ±3,46	23,44 (18,41 s/d 31,1)
Overweight	8(16%)		
Obesity grade I	16(32%)		
Obesity grade II	2 (4%)		
Joint Space Width, mm		2,42 ± 1,59	2,93 (0,0 s/d 5,05)
Grade OA,n (%)			
I	11 (22%)		
II	19 (38%)		
III	10 (20%)		
IV	10 (20%)		

Table 3: Distribution of OA Grade Based on Age, Sex, and Occupation in Patients

Characteristics		*Grade* OA			
	I	II	III	IV	P Value
Age					
<40	2 (40%)	3 (60%)	0 (0%)	0 (0%)	0,290*
≥40	9 (20%)	16 (35,6%)	10 (22,2%)	10 (22,2%)	
Gender					
Woman	8 (23,5%)	13 (38,2%)	5 (14,7%)	8 (23,5%)	0,519*
Man	3 (18,8%)	6 (37,5%)	5 (31,3%)	2 (12,5%)	
Occupation					
Indoor	7 (17,5%)	16 (40%)	8 (20%)	9 (22,5%)	0,444*
Outdoor	4 (40%)	3 (30%)	2 (20%)	1 10%)	
Body Mass Index (BMI)					0,093*
Normoweight	8 (33,3%)	12 (50%)	2 (8,3%)	2 (8,3%)	
Overweight	2 (25%)	3 (37,5%)	2 (25%)	1 (12,5%)	
Obesitas *Grade I*	1 (6,3%)	4 (25%)	5 (31,3%)	6 (37,5%)	
Obesitas *Grade II*	0 (0%)	0 (0%)	1 (50%)	1 (50%)	

**Chi-square test*

Table 4: Distribution of Mean Femoro-Tibial Joint Space Width Based on Age, Sex, and Occupation in Patients with Knee Osteoarthritis

Karakteristik	Rerata Lebar Celah Sendi (± SD)	Nilai P
Age		0,308*
<40	3,3 (±0,49)	
≥40	2,3 (±1,65)	
Gender		0,519*
Woman	2,5 (±1,65)	
Man	2,2 (±1,50)	
Occupation		0,308*
Indoor	2,2 (±1,60)	
Outdoor	2,9 (±1,53)	
Body Mass Index (BMI)		0,000**
Normoweight	3,3(±1,33)	
Overweight	2,2 (±1,32)	
Obesity Grade I	1,3 (±1,31)	
Obesity Grade II	0,4 (±0,19)	
***Grade* OA**		0,000**
Grade I	4,1(±0,51)	
Grade II	3,1(±0,73)	
Grade III	1,4(±0,91)	
Grade IV	0,1(±0,16)	

* Mann-Whitney U test
**Kruskal-Willis test

Before performing inferential analysis test, a normality test was conducted. Because the sample size was 50, the Shapiro-Wilk test was applied to assess the normality of the joint space width and BMI variables. The significance value for BMI was 0.66 ($p > 0.05$), indicating that the data were normally distributed. In contrast, the significance value for joint space width was 0.002 ($p < 0.05$), suggesting that the data were not normally distributed. Since one of the variables did not follow a normal distribution, a non-parametric correlation test—Spearman's rank correlation—was used instead of Pearson's. The Spearman correlation test revealed a significant negative association between Body Mass Index (BMI) and femorotibial joint space width among patients with knee osteoarthritis undergoing X-ray examination at Adam Malik General Hospital, Medan (rho = -0.533, $p < 0.01$). This indicates that higher BMI values are associated with narrower femorotibial joint space. The strength of this correlation is moderate and statistically significant at the 99% confidence level ($p < 0.01$). Following the identification of a significant correlation between BMI and femorotibial joint space width, a simple linear regression analysis was performed to determine the extent to which BMI could predict changes in femorotibial joint space width. The results of the regression analysis are presented in Table 5.

Tabel 5: Hasil regresi linier IMT dengan ukuran celah sendi femorotibial

Components	Value
R	0,554
R Square	0,306
Adjusted R Square	0,292
Std. Error of Estimate	1,345
F (ANOVA)	21,212
Sig. (p-value)	0,000
Koefisien IMT (B)	-0,255
Sig. Koefisien IMT	0,000
Konstanta (Intercept)	8,577

Based on Table 5, the correlation coefficient (R) was 0.554, and the coefficient of determination (R Square) was 0.306, indicating that 30.6% of the variation in femorotibial joint space width can be explained by changes in BMI. The remaining 69.4% is explained by other factors. The regression coefficient for the BMI variable was -0.255 with a p-value of 0.000 ($p < 0.05$), indicating statistically significance. This suggests that for every 1 kg/m² increase in BMI, there is a decrease of 0.255 mm in femorotibial joint space width. Based on the BMI coefficient (B) and the constant, the linear regression equation can be described as: $y=8.577-0.255x$, where y is the femorotibial joint space width (mm) and x is the Body Mass Index (BMI). The F-test result from the ANOVA table shows that the regression model is significant, with an F-value of 21.212 and a p-value of 0.000 ($p < 0.05$). This means that the regression model can be used to predict joint space width based on BMI.

In this study, among a total of 50 patients, the majority were female (68%) and aged 40 years or older (90%), with most having indoor occupations (80%). This aligns with literature stating that knee osteoarthritis (OA) is more prevalent in females and older individuals due to hormonal influences, cartilage degeneration with aging, and biomechanical factors (Pallazzo, 2016). Furthermore, a systematic review by Tschon et al. (2021) explained that sex is not just a confounding factor in OA, particularly knee OA, but also a significant one to consider. They noted that women are more likely to experience OA due to differences in estrogen levels and femorotibial curvature compared to men. Estrogen provides a biochemical protective effect on joint cartilage. Similarly, a study by Peshkova et al. (2022) also stated that women are more prone to OA than men. Indoor jobs, which typically involve less physical activity, are not believed to directly affect the onset of OA but may contribute through increased risk of obesity due to low physical activity (Dare, 2015). This relationship is supported by a study by Huang (2024), which found that subjects with low physical activity had a higher risk of OA compared to those with moderate activity. However, in this study, subjects with moderate activity levels tended to have normal BMI compared to those with low activity levels. Based on Kellgren-Lawrence OA grading, most patients were in grade II (38%), followed by grade I (22%), and grades III and IV each at 20%. This indicates that most patients presented with early to moderate stages, suggesting potential for symptom improvement through conservative management. The average BMI of the patients in this study was 24.09 kg/m², falling within the normal-to-overweight category. Higher average BMI was observed in females and individuals aged 40–59 years. This supports the notion that excess body weight, particularly in the productive age group, is a significant risk factor for developing knee OA. The meian femorotibial joint space width was 2.93 mm, indicating narrowing of the joint space consistent with OA diagnosis. The smallest median joint space was found in patients aged ≥60 years, males, and those with indoor occupations. Joint space narrowing reflects the degree of articular cartilage damage and is presumed to be more severe in older patients due to chronic degenerative processes. Interestingly, although females outnumbered males in this study, males showed a smaller median joint space. This could suggest that while the incidence of knee OA is higher in females, the progression and severity of damage may be greater in males, possibly due to lifestyle factors or delayed treatment-seeking behavior. This is in line with a study by Abdullah (2021), which found that males tend to have poorer health-seeking behaviors compared to females, especially in chronic diseases, and particularly among those with lower education or socioeconomic status. While this study did not delve into educational or economic status, knee OA being a chronic disease may explain the narrower joint space seen in male patients in this study.

The Spearman correlation test showed a significant negative relationship between BMI and femorotibial joint space width ($r = -0.533$, $p < 0.01$). This indicates that as BMI increases, joint space width decreases, suggesting more severe knee OA. The correlation was moderate and statistically significant. These findings are consistent with the study by Shumnalieva (2022), which showed that obesity contributes to OA progression through mechanical loading and metabolic pathways. A more recent study by Zeng et al. (2021) confirmed that obesity is significantly associated with joint space narrowing in knee OA patients, both through increased mechanical pressure on the medial knee compartment and via systemic inflammatory mediators. In that study, patients with BMI ≥30 kg/m² had an average joint space width reduction of 0.27 mm compared to the normal-weight group, after adjusting for age and gender. Furthermore, the regression analysis in this study demonstrated that 30.6% of the variation in joint space width could be explained by BMI ($R^2 = 0.306$), and the linear regression model showed that each 1 kg/m² increase in BMI was associated with a 0.255 mm reduction in joint space width. This provides strong evidence that BMI is not only associated with but can also predict the severity of knee OA in a radiologic context. These findings are also in agreement with the perspective of Conrozier et al. (2020), who emphasized that adiposity contributes not only to mechanical stress but also triggers the release of pro-inflammatory cytokines such as IL-6 and TNF-α, which accelerate cartilage degeneration (Zhang, 2020; Nishimura, 2021). However, this study has several limitations, including a relatively small sample size and single-center design (only conducted at Adam Malik Hospital), which may limit the generalizability of the findings to broader populations, particularly in areas with different healthcare settings. Additionally, due to the cross-sectional design, this study cannot establish a direct causal relationship between BMI and knee OA, nor can it assess OA progression over time. Moreover, the number of subjects in each characteristic group (age, gender, occupation type, and BMI) was uneven. This imbalance may affect the results by allowing potential confounding effects from other factors, such as age or physical activity, on joint space width aside from BMI alone.

CONCLUSSION

There is a significant negative correlation between Body Mass Index (BMI) and femorotibial joint space width in patients with knee osteoarthritis (rho = -0.533, $p < 0.01$) who underwent X-ray examination at Adam Malik Hospital, Medan. This relationship is described by the regression equation $y = 8.577 - 0.255x$, where y represents the femorotibial joint space width and x represents the Body Mass Index (BMI).

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