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Ultrasound assessment of femoral cartilage thickness among healthy Indonesian adults

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Ultrasound assessment of femoral cartilage thickness among healthy Indonesian adults

Rita Vivera Pane[1*], Aisyah[2], Hajar Ariani[3], Erwien Isparnadi[4], Aufar Zimamuz Zaman Al Hajiri[5], Albert Setiawan[6]

ABSTRACT

Background: Ultrasound (US) is a reliable, non-invasive, and inexpensive modality for evaluating femoral cartilage (FC) thickness. Several studies evaluated the US accuracy in assessing FC thickness by comparing it to MRI and macroscopic measurements, reporting that the US exhibit highly accurate FC thickness measurement. This study evaluated the FC thickness among healthy Indonesian adults using ultrasound US assessment.

Methods: An analytical observational study with a cross-sectional design was conducted in Surabaya Hajj General Hospital, Indonesia, from April to August 2022. A total of 127 participants with no symptoms or pathologies on both knees were involved in the study. In this study, a certified examiner performed the ultrasound scanning in three sites: medial condyle (MC), intercondylar (IC), and lateral condyle (LC) of both knees.

Results: A total of 254 knees from 127 healthy Indonesian adults were examined. The participants' mean age was 32.83 years. Most of them were female (69%). Participants' average weight, height, and BMI were 62.25 kg, 161.17 cm, and 23.93, respectively. The mean FC thickness of the right MC, IC, and LC was 1.76 mm, 1.92 mm, and 1.71 mm, respectively. Meanwhile, the mean FC thickness of left MC, IC, and LC was 1.76 mm, 1.89 mm, and 1.69 mm, respectively. This study found that FC thickness was associated with gender (<0.05) but not age and BMI.

Conclusion: Mean FC thickness among healthy Indonesian adults of MC, IC, and LC were 1.76 mm, 1.89 – 1.92 mm, and 1.69 – 1.71 mm, respectively. The IC mean was higher than the MC and LC means. Mean FC thickness on both sides was associated with gender but not age and BMI.

Keywords: *femoral cartilage thickness, knee, ultrasound.*

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INTRODUCTION

Ultrasound (US) is widely used to evaluate and assess the pathology in the musculoskeletal system. This method is superior to other conventional imaging methods due to its portable and real-time features. It allows examiners to flexibly evaluate many sites and conditions the conventional imaging method could not reach. This method is capable of evaluating soft tissue, bone contours in joints, cartilage, meniscus, and various pathological conditions like osteophytes, synovial hypertrophy, and effusion, among other conditions.[1,2] Although MRI is superior to the US in evaluating soft tissue, it should be noted that not all patients are eligible to undergo MRI due to their conditions or healthcare facility limitations. Ultrasound is a reliable, non-invasive, and inexpensive modality for evaluating femoral cartilage (FC) thickness.[3–5] Several studies evaluated the US accuracy in assessing FC thickness by comparing it to MRI and macroscopic measurements, reporting that the US exhibit highly accurate FC thickness measurement. Ultrasound can evaluate the FC thickness in the medial, intercondylar, and lateral, the best sites to measure the knee cartilage thickness.[6,7]

Previous studies evaluated FC thickness among healthy populations in their countries.[8–10] In this regard, it is necessary to develop a database of the normal FC thickness among the Indonesian population that allows physicians to identify and predicts the possibility of pathological knee condition in the future. This study aims to evaluate and provide a database of FC thickness among healthy Indonesian adults.

METHODS

This cross-sectional, observational analytical study was conducted in the Physical Medicine

and Rehabilitation Department, Surabaya Hajj General Hospital, Indonesia, from April to August 2022.

Study population

This study involved 127 participants, including medical students, medical doctors, physiotherapists, employees, and patients with no knee symptoms, a clinical sign of osteoarthritis, or any other pathologies on both knees. The participants below seventeen years of age, those with a history of osteoarthritis, rheumatoid arthritis or other autoimmune diseases, and knee injury were excluded from this study. All participants underwent history taking and physical examination by a physiatrist. Informed consent was obtained from all participants.

Ultrasound imaging technique and analysis

All scanning was performed using Canon Xario 100 with a 7.2-14 MHz linear transducer (Type 18L7) 2D Ultrasound device. Focus and depth were set according to the patient's conditions. An examiner performed a standard US of the knee joint to assess FC. The examiner was an experienced and trained physiatrist certified in Ultrasound for Interventional Pain Management by Indonesian Physiatrist Collegium, number 011/SKTIPM/IKFR/III/2019. A Femoral Cartilage thickness scan was performed in a supine position with full flexion of the knee joint in each patient. The probe was placed between the medial and lateral condyle of the distal femur with transversal scanning. The FC was measured in three sites: medial condyle (MC), intercondylar (IC), and lateral condyle (LC) by caliper feature attached to the US device, presented in millimeters.

Data Analysis

Data were collected using Microsoft Excel 365 version, while statistical analysis was performed using IBM SPSS version 26. General data such as age, gender, and BMI were analyzed descriptively. There were six participants' age groups in this study: from 17-25, then ten years interval for each group, to 65 years above. Body mass index (BMI) was evaluated from participants' height and weight, measured after US scanning, and grouped following Asia-Pacific BMI classification, i.e., underweight, normal, overweight, and obese. The FC thickness was evaluated on the right and left knees' MC, IC, and LC and presented as mean ± SD. The normality test was performed using the Kolmogorov-Smirnov test and showed non-normal distribution. The correlation between FC thickness and age and BMI was analyzed using Spearman Test, while the correlation between FC thickness and gender were analyzed using the Mann-Whitney test. A p-value < 0,05 indicates a significant result.

RESULTS

This study evaluated 254 knees of 127 healthy Indonesian adults. Data on age, gender, weight, height, BMI, and mean FC thickness of both knees were recorded (Table 1). Most participants in this study were in the younger age group, which may be associated with the exclusion of older participants with clinical knee symptoms. The FC thickness was evaluated in terms of participants' age, gender, and BMI (Table 2-4). Statistical analysis showed a significant correlation between FC thickness and gender (< 0,05) but no correlation between FC and age and BMI.

DISCUSSION

This study focuses on evaluating the FC thickness of healthy Indonesian adults. To our knowledge, no similar study has been published in the Indonesian context. The database describes the FC thickness of Indonesian, which can be a predictor of knee health among Indonesian adults. As shown in Table 1, the mean FC thickness among healthy Indonesian adults in RMC, RIC, RLC, LMC, LIC, and LLC was 1.76 mm, 1.92 mm, 1.71 mm, 1.76 mm, 1.89 mm, and 1.69 mm, respectively. The IC mean was thicker than the MC mean, while the MC mean was thicker than the LC mean in both knees. This study supports previous studies reporting that IC (also known as middle site or intercondylar notch) is thicker than MC and LC.[9,10]

Compared to previous studies, the mean FC thickness of Indonesian is thinner than Korean, Saudi Arabian, and Turkish

Table 1. General data of participants.

Variable	Results
Age, years (mean ± SD)	32.83 ± 13.67
Age group, years (n, %)	
17-25	69 (54%)
26-35	16 (13%)
36-45	17 (13%)
46-55	15 (12%)
56-65	5 (4%)
>65	5 (4%)
Gender (n, %)	
Male	39 (31%)
Female	88 (69%)
Weight, kg (Mean ± SD)	62.26 ± 13.25
Height, cm (Mean ± SD)	161.17 ± 7.79
BMI (Mean ± SD)	23.93 ± 4.64
Right Femoral Cartilage Thickness, mm (Mean ± SD)	
Medial condyle	1.76 ± 0.33
Intercondylar	1.92 ± 0.39
Lateral condyle	1.71 ± 0.31
Left Femoral Cartilage Thickness, mm (Mean ± SD)	
Medial condyle	1.76 ± 0.34
Intercondylar	1.89 ± 0.34
Lateral condyle	1.9 ± 0.33

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Table 2. Femoral cartilage thickness based on age.

Age	Mean femoral cartilage thickness (mm)					
	RMC	RIC	RLC	LMC	LIC	LLC
17-25	1.74	1.98	1.78	1.74	1.93	1.73
26-35	1.58	1.81	1.75	1.76	1.81	1.65
36-45	1.62	1.93	1.71	1.74	1.87	1.68
46-55	1.83	1.88	1.86	1.9	1.83	1.7
56-65	1.54	1.64	1.7	1.64	1.84	1.66
>65	1.78	1.64	1.56	1.84	1.84	1.64

Table 3. Femoral cartilage thickness based on gender.

Gender	Mean Femoral Cartilage Thickness (mm)					
	RMC	RIC	RLC	LMC	LIC	LLC
Male	1,83	2.1	1.86	1.97	2.05	1.86
Female	1.66	1.83	1.72	1.67	1.82	1.61

Table 4. Femoral cartilage thickness based on BMI.

BMI	Mean femoral cartilage thickness (mm)					
	RMC	RIC	RLC	LMC	LIC	LLC
Underweight	1.65	1.82	1.68	1.69	1.81	1.61
Normal	1.77	1.94	1.71	1.82	1.91	1.69
Overweight	1.79	1.94	1.88	1.81	2	1.75
Obese	1.77	1.9	1.65	1.69	1.84	1.68

populations.[8–10] There were differences in anthropometric measurement standards in the Indonesian population. In another case, such as growth in children, a meta-analysis showed that Indonesian children fell under the categories of 'stunted' and 'very stunted' according to World Health Organization Child Growth Standards (WHOCGS), yet categorized as 'normal' according to the Indonesian Growth Reference Chart (IGRC). The IGRC is Indonesia's national growth reference standard that includes anthropometric data of children from thirty-three Indonesian provinces. The difference between both curves is still unknown, which can be attributed to genetic and environmental factors.[11] An interesting finding is reported by Pontoh et al., who predict the Anterior Cruciate Ligament (ACL) length using anthropometric data, showing that ACL length among Asian is shorter than in Western populations.[12] Rumapea et al. predicted Indonesian children's stature by measuring their knee height, showing that knee height can be used to predict stature.[13] These findings may be related to FC thickness.

Age is associated with degenerative processes of all organs, including the knees. Aging directly correlates with knees, organs that bear most of the body weight longer. Several studies concluded that FC thickness was associated with aging, and the condition was worse in people who lacked physical activity or exercise.[8,10] This study result is in line with Sidharthan et al. in their MRI-based study, reporting a significant relationship between aging and FC thickness.[14]

Anatomical differences, including cartilage structure, between male and female participants were noticed. This difference predisposes to an increased risk of cartilage degeneration in females.[15] Several studies showed that women have thinner cartilage than men.[9,10,16,17] A deep learning MRI-based study examining FC thickness concluded that male FC was thicker than females in all age groups.[18] Gau et al., who measured FC thickness among American school-aged children, reported that boys have thicker FC than girls.[19]

No correlation between FC thickness and BMI was found, supporting Herrera et al., who also reported no significant relationship between BMI and FC thickness. It may be accounted for by a mean BMI of 23.94, which is not categorized as obese, and a limited number of obese participants enrolled.[20] Knees are known to support most of the body weight. As knee health is affected by BMI, high BMI increases the risk of knee pathology. Obesity leads to increased cartilage wear in the patellofemoral compartment.[21] Obesity affects knee mechanical loads and cartilage thickness, including FC thickness. Pamukoff et al. showed that joint load and FC thickness were related to BMI. In addition to imposing more loads on joints, obesity is associated with inflammatory factors that increase the risk factors of cartilage damage. Obese adults are reported to have increased Adipokine, which is associated with changes in cartilage structure. Collins et al. reported a significant relationship between body composition and the biomechanical and biochemical properties of cartilage. These findings suggest that changes in cartilage stretch result from biomechanical changes (increased joint load), while cartilage composition changes (loss of proteoglycans) cause mechanical changes.[22–24]

This study is consistent with Babayeva et al., who found a significant and positive correlation between FC thickness and body weight in athletes. Evidence suggests that a decrease in cartilage thickness occurs due to muscle weakness and changes in the cross-sectional area of thigh muscle caused by prolonged non-loading activities.[4]

The limitation of this study lies in the participants' composition, in which most of them were from East Java Province and might not be representative of the FC thickness of the Indonesian population. Therefore, future studies are strongly recommended to involve a larger sample and employ multicenter studies.

CONCLUSION

Mean FC thickness among healthy Indonesian adults regarding MC, IC, and LC were 1.76 mm, 1.89 – 1.92 mm, and 1.69 – 1.71 mm, respectively. Mean IC was thicker than mean MC and LC on both sides. This study showed that the mean FC thickness among Indonesian adults was thinner than Korean, Saudi Arabian, and Turkish populations, supporting previous findings that Asian ACL length is

shorter than Western populations. Mean FC thickness was correlated with gender but not age and BMI on both knees. Future studies are strongly recommended to involve a larger sample and apply a multicenter study.

ETHICAL CONSIDERATIONS

This study was conducted with ethical approval from Surabaya Hajj General Hospital Ethical Committee, number No. 073/07/KOM.ETIK/2022.

FUNDING

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CONFLICT OF INTEREST

The authors declare no conflicts of interest in this work.

AUTHOR CONTRIBUTION

All authors have made the same contribution in writing the report on the results of this study, from the stage of proposal preparation, data search, and data analysis, to the interpretation of research data and presentation of the final report.

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