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Exploring the correlation between body mass index and knee Hoffa fat pad size in MRI sagittal plane

Cumhur Deniz Davulcu[a], Arin Celayir[a,*]

[a]*Istanbul University-Cerrahpasa, Cerrahpasa Faculty of Medicine, Department of Orthopaedics and Traumatology, Istanbul, Türkiye*

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Abstract

Aim: The relationship between body mass index (BMI) and knee Hoffa fat pad size has garnered increasing attention due to its potential implications in orthopedic pathology. This study aimed to explore the correlation between BMI and Hoffa fat pad size as measured on MRI sagittal plane images.

Materials and Methods: A retrospective analysis was conducted on MRI scans of the knee joint from a cohort of patients. Sagittal plane images were reviewed, and the size of the Hoffa fat pad was measured using standardized techniques. BMI data were collected from patient records. Correlation analysis was performed to assess the relationship between BMI and Hoffa fat pad size.

Results: A total of 60 MRI scans were included in the analysis. The mean BMI of the cohort was Y 29.7990. The mean size of the Hoffa fat pad was 29.7990. The age range was between 45 and 75. Correlation analysis revealed a statistically significant positive correlation between age and Hoffa fat pad size ($p < 0.05$). Specifically, as age increased, there was a corresponding increase in the size of the Hoffa fat pad.

Conclusion: This study provides evidence of a positive correlation between age and Hoffa fat pad size as observed on MRI sagittal plane images. No significant relationship was found between body mass index and Hoffa fat pad size. Further research is warranted to elucidate the underlying mechanisms and clinical implications of this relationship.

Introduction

The Hoffa fat pad, also referred to as the infrapatellar fat pad, is an important structure located within the knee joint. Positioned behind the patella and in front of the knee joint, this specialized mass of adipose tissue plays several crucial roles in the biomechanics and functionality of the knee. Acting as a shock absorber, it helps cushion the joint during movement, providing a degree of protection and stability. Its strategic placement contributes to the smooth operation of the knee, although it can be prone to inflammation and injury, leading to discomfort and contributing to various knee-related issues [1,2]. Understanding the role and characteristics of the Hoffa fat pad is integral to comprehending certain knee conditions and devising appropriate treatment strategies [3].

It plays a crucial role in providing cushioning and support to the knee, but its association with Body Mass Index (BMI) remains a subject of interest and investigation.

This article delves into the correlation between BMI and the length of the Hoffa fat pad as observed in MRI sagittal plane images. BMI is a widely used metric for assessing body weight relative to height [4]. As obesity rates continue to rise globally, understanding the implications of excess body weight on joint health becomes increasingly important. Excess adiposity is known to exert mechanical stress on weight-bearing joints, potentially influencing the morphology and function of surrounding structures. The Hoffa fat pad, situated within the knee joint, is implicated in various pathological conditions, including Hoffa's syndrome. This syndrome involves impingement or inflammation of the fat pad, leading to pain and discomfort. Investigating the relationship between BMI and the Hoffa fat pad length could provide valuable insights into the mechanisms underlying Hoffa's syndrome and related knee disorders.

Materials and Methods

In this retrospective study, data from 60 patients were evaluated. The radiographic grading system and MRI sagittal images were utilized. Between 2016 and 2022, patients meeting the inclusion criteria were enrolled in the study group. Patients with a history of surgery for tumoral, arthroscopic, or traumatic knee conditions were excluded from the study. Additionally, patients who had un-

*Corresponding author:
Email address: arin.celayir@iuc.edu.tr (Arin Celayir)

dergone total hip arthroplasties due to hip fractures were also excluded from the study to ensure homogeneity in the knee-specific analysis. The sample size of 60 was determined based on a power analysis to detect a moderate effect size (Cohen's d = 0.5) with 80% power and a significance level of $\alpha = 0.05$, ensuring adequate representation for statistical comparisons.

MRI scans were acquired using Siemens Healthcare Erlangen, Germany's 1.5 T Magnetom MRI equipment. A sagittal medium-weighted fat-suppressed turbo spin-echo sequence (IW TSE; repetition time = 3,200 ms, echo duration = 30 ms, slice thickness = 3.0 mm, in-plane resolution = 0.36 mm x 0.36 mm) was used for dimensional analysis of the Hoffa fat pad. Manual adjustments to brightness, intensity, contrast, and gray values were performed to optimize the contrast between the Hoffa fat pad and surrounding tissues.

The maximal sagittal thickness (depth) of the infrapatellar fat pad (IPFP) was measured manually for both the right and left knees. This was achieved by drawing a line perpendicular to the patellar tendon, extending from the anterior to the posterior surface of the Hoffa fat pad (Figure 1).

Figure 1. Demonstration of Hoffa fat pad measurement in the sagittal plane on MRI.

Expected outcomes

Based on existing literature, it is hypothesized that individuals with higher BMI may exhibit longer Hoffa fat pads. This expectation is rooted in the increased mechanical loading experienced by the knee joint in individuals with excess body weight.

This retrospective study included all available patients in the database and hypothesized that there is a difference in mean edema levels in the Hoffa fat pad between males and females that BMI is correlated with edema in the Hoffa fat pad, and that age is correlated with edema in the Hoffa fat pad.

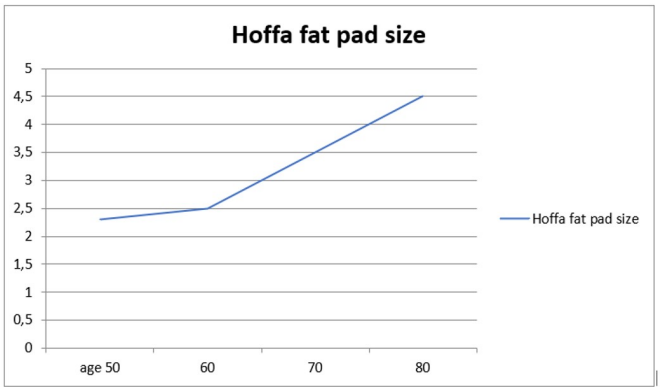

Figure 2. Figure showing the relationship between age and the Hoffa fat pad.

Clinical implications

Understanding the correlation between BMI and Hoffa fat pad length has potential clinical implications. Clinicians may use this information to assess the risk of knee disorders in patients with elevated BMI, guiding preventive measures and personalized treatment plans.

Results

In our statistical analysis, we found that the Hoffa fat pad only increased significantly with age. We observed that the patient's BMI or gender did not significantly affect the Hoffa fat pad (Table 1-2-3).

Gender – Edema: No significant relationship (p = 0.401, t-test).

BMI – Edema: No significant relationship (p = 0.62, Pearson correlation).

Age – Edema: Significant relationship ($p<0.01$, r = 0.47, Pearson correlation).

Discussion

The correlation between Body Mass Index (BMI) and the length of the Hoffa fat pad in MRI sagittal plane images is an area of significant interest and relevance in orthopedic and radiological research. Several studies have aimed to explore the relationship between BMI and the Hoffa fat pad due to the potential implications for knee health and pathology [1-2].

Table 1. Normality checked by Shapiro-Wilk test

	Test of normality					
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Edema	.084	40	.200*	.984	40	.819
BMI	.091	40	.200*	.976	40	.527
Age	.170	40	.005	.877	40	.000

*: This is a lower bound of the true signifance.

[a]: Lilliefors Significance Correction.

Table 2. For non-normally distributed data (age), median, interquartile range, and 95% confidence interval.

	One-Sample Test Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Edema	16.022	39	.000	81.32175	**71.0551**	**91.5884**
BMI	56.558	39	.000	29.49000	**28.4353**	**30.5447**

Table 3. This table provides a detailed summary of the descriptive statistics for the age variable in the study population, highlighting central tendency, dispersion, distribution shape, and variability.

Descriptives				
			Statistic	Std. Error
Age	Mean		50.9750	1.15663
	95% Confidence Interval for Mean	Lower Bound	48.6355	
		Upper Bound	53.3145	
	5% Trimmed Mean		51.0833	
	Median		53.0000	
	Variance		53.512	
	Std. Deviation		7.31520	
	Minimum		40.00	
	Maximum		60.00	
	Range		20.00	
	Interquartile Range		**15.50**	
	Skewness		-.263	.374
	Kurtosis		-1.532	.733

Ratio Statistics for age / unit 95% Confidence Interval for Median			
Median	*Lower Bound*	*Upper Bound*	Actual Coverage
53.000	**47.000**	**57.000**	96.2%

One key observation in these studies is the association between increased BMI and alterations in the Hoffa fat pad length and morphology. Research indicates that individuals with higher BMIs often exhibit larger Hoffa fat pads, suggesting a potential link between adiposity and changes in this structure within the knee joint. This increase in fat pad size is thought to be a consequence of increased adipose tissue deposition in the Hoffa fat pad, which could lead to mechanical alterations, inflammation, or metabolic changes within the knee joint [3].

However, while there seems to be a general trend indicating a positive correlation between BMI and Hoffa fat pad size, the relationship is not absolute and can vary among individuals. Some studies have reported conflicting findings, suggesting that factors beyond BMI, such as age, gender, or specific metabolic conditions, might influence the size and characteristics of the Hoffa fat pad [4]. Moreover, the clinical significance of the correlation between BMI and Hoffa fat pad length remains a subject of ongoing investigation. Understanding this correlation could potentially aid in predicting knee-related pathologies, assessing the risk of certain conditions like Hoffa's syndrome, or even guiding treatment strategies in patients with higher BMIs [5].

BMI is the best and most recommended way to measure obesity, it is only regarded as a rough guideline since not everyone has the same amount of obesity based on their fat rates.

Although WHO has determined obesity criteria according to BMI values, the fat percentage is different in each patient. Fat ratio and distribution can be evaluated in patients with high BMI using methods such as SCAT subcutaneous adipose tissue and PPF: preperitoneal fat. Apart from conditions such as hepatosteatosis and cardiovascular diseases caused by obesity, the main reason for the increased relationship in osteoarthritis can be predicted as heterogeneous fat distribution in the body [6].

It has been demonstrated to affect joint loading, which is the main risk factor for osteoarthritis (OA). However, it can also cause metabolic alterations that are marked by persistent low-level inflammation because of elevated amounts of "adipokines," or cytokines produced from adipose tissue, in the blood. The infrapatellar fat pad in the knee raises the possibility that local variations in adipokine levels might impact knee OA [7].

Although the biomechanics of joint degeneration caused by the mechanical effect of obesity over the years are known,

the effect of inflammatory cytokines on the joint is still being investigated. Serum levels of cytokines such as IL-1,6, TNF-α and leptin are high in obese patients, but the local effect of these adipokines is unknown. If it has a local effect, it has not yet been clarified where this cytokine discharge in the joint originates. Hoffa fat pad may be responsible for this adipokine discharge. In our study, we tried to examine the effect of the Hoffa pad by evaluating similar BMI groups in a homogenized manner. The results of our study suggested a connection between body weight, BMI, and the existence of OA and the size of the Hoffa fat pad. These results imply that whereas fat pad size alone does not predict osteoarthritis (OA), it is associated with OA as a consequence of total body fatness.

The association between age and the size of the Hoffa fat pad was additionally investigated in our research. The correlation between this and BMI has been determined to be lower. People whose fat pads expand in size as they age may be more susceptible to osteoarthritis (OA), according to the literature's association between fat pad size and age. Despite the lack of a relationship between elevated BMI and fat pad volume, aging is associated with increased lymphocyte infiltration in the infrapatellar fat pad [8].

Patients with osteoarthritis have synovial fluid that contains high amounts of leptin. Additionally, the amount of leptin in synovial fluid is correlated with the severity of the illness, and individuals with osteoarthritis (OA) had considerably greater levels of leptin expression in both Hoffa pad. Therefore, it is reasonable to hypothesize that differences in Hoffa pad thickness and shape, which result in a shift in the quantity of adipose tissue cells, may produce changes in the amounts of inflammatory cytokines, which in turn may cause articular tissue pathology, as seen in osteoarthritis of the knee [9-10].

The limitation of our study is that the signal increase due to inflammation in the Hoffa fat pad and the amount of arthrosis affected by this inflammation were not evaluated. This will be the subject of future studies.

Conclusion

This study aims to contribute to the growing body of knowledge surrounding the interplay between BMI and knee joint health. By exploring the correlation with the Hoffa fat pad length in MRI sagittal plane images, we aspire to enhance our understanding of the musculoskeletal consequences of obesity and inform strategies for better patient care. These insights could facilitate early diagnosis of obesity-related knee conditions and support the development of tailored interventions to improve joint health and overall mobility in affected individuals.

Ethical approval

The study was approved by the Ethics Committee of Istanbul Unıversity-Cerrahpasa, Cerrahpasa Faculty of Medicine (Date: 18.09.2024, decision number: 1094735).

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