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ORIGINAL ARTICLE

High Body Mass as a Weight Factor for Hip Osteoarthritis Progression: Insights into Challenges, Strategies, and Consequences

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ABSTRACT

Background. Obesity raises the risk of various debilitating, degenerative diseases, particularly osteoarthritis. The ablative impact on subchondral cartilage in weight-supporting joints induces osteoarthritis (OA) pain and reduced function. **Objectives.** Hip osteoarthritis diagnosis and propensity using two self-administered questionnaires: the 12-item osteoarthritis-perception questionnaire and the Western Ontario and McMaster Universities (WOMAC) Osteoarthritis Index. Setting: University Sains Malaysia, Malaysia. **Methods.** Seventy patients aged 18 to 79 visiting Hospital-USM participated in this prospective cross-sectional study investigating obese patients' susceptibility to hip osteoarthritis (HOA). Obesity was defined as BMI >30 kg/m^2. **Results.** Of the 70 patients recruited, 40 were obese, while 30 were non-obese. Females were the most likely to be obese (57.1%), and the average age was 53.2 years (SD 7.1). The mean BMI of the OA group (YES-HOA) was 42.14 (SD 3.24), which was significantly more significant than the mean BMI of the group without osteoarthritis (NO-HOA), which was 30.95 (SD 0.51) (p-value =0.001). Among the YES-HOA group, 84.6% were obese. There was a 12-point reduction in the overall WOMAC score between the two groups, and the obese group (OG) had a significantly higher overall mean WOMAC score than the non-obese group (NOG) (64 (SD 22) vs. 52 (SD 21) respectively). Further, the mean WOMAC scores for the three HOA joint features were higher for the OG than the NOG (61 (SD 20) vs. 54 (SD 19) for pain, 54 (SD 19) vs. 61 (SD 20) for stiffness, and 51 (SD 11) vs. 71 (SD 24) for reduced function respectively; p-value <0.05 for all). Both of the investigation tools demonstrated the obese patients' susceptibility to the onset and progression of hip osteoarthritis. **Conclusion.** Obesity is associated with an increased likelihood of OA, but whether it causes the onset of the condition or exacerbates its progression remains unclear.

KEYWORDS: ***Hip Osteoarthritis, Arthritis, Obesity, BMI, WOMAC.***

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INTRODUCTION

Osteoarthritis (OA) is the most common joint disorder among adults and is acknowledged as the fourth most prevalent cause of disability globally (1). OA results from an inflammatory process and the associated degeneration of joint cartilage and the inherent bone. The early limited diagnosis has widened, with OA now recognized as a disease affecting all joints and supporting structures, including the bony network, muscles, and their tendons, supporting ligaments, and the synovium (2). Although the etiology of osteoarthritis can be multi-factorial depending on the type (primary or secondary), the primary risk factors are mechanical, biochemical, and genetic. Among the latter, obesity is considered the most crucial indicating factor for OA. Fortunately, it is also considered one of the most controllable risk instigators.

Obesity is a progressive, widespread, and chronic disorder with considerable potential undesirable consequences, mainly its association with OA and other comorbidities, and this is very problematic to health governing bodies worldwide (3, 4). Obesity is a global plague that has resulted from changes in human dietary intake, lifestyle, and social norms, which are linked with several established multi-factorial etiologies of the condition (5, 6). Obesity classifications vary, but the most commonly used was developed by the World Health Organization (WHO), which classifies overweight/obesity as a body mass index (BMI) of > 30 kg/m^2 (7, 8). In 2016, the WHO global estimation was that more than 1.9 billion adults aged 18 or over were overweight, and among these, more than 650 million were obese. Overall, approximately 13% of the global adult population (11% of adult men and 15% of adult women) were living with obesity in 2016, and the total prevalence of obesity had almost tripled from 1975 to 2016 (9, 10). Obesity is considered to be among the leading conditions that contribute to early death (11).

Osteoarthritis (OA) is the most common type of arthritis and cause of joint problems, particularly in weight-reliant areas such as the hip and knee joints (1). It is unclear, however, why the condition is escalating. It is an under-acknowledged public health dilemma; for several decades, the prevalence of arthritis (particularly in the hip, HOA, and in the knee, KOA) has been growing at an alarming rate, in conjunction with the rising obesity epidemic, especially among adults aged 45–64 years old (12, 13). The degenerative tendency of OA leads to morphological damage to joint tissues, making the collagen matrix of the joint more disorganized and causing proteoglycan reduction as well as an imbalance of the hydrostatic-osmotic pressure in the joint. This eventually increases the water content (water inflow), further exacerbating the ongoing degenerative process, leading to inflammation of the synovium and joint capsule and resulting in joint features that characterize OA (14). Joint destruction from mechanical insult coupled with deficient self-repair by joints is regarded as a root cause of OA; insult contributions may be caused by bone misalignments from congenital or pathogenic causes, mechanical harm, obesity, muscle strength loss for joint support, and peripheral nerve damage leading to sudden or uncoordinated movements (15). It seems clear that the risk of OA increases with aging and obesity (16).

While some scholars have described the association between OA and obesity as incoherent Jiang, Xie (17), others uphold a robust association (18). It is indisputable that obesity is linked with lots of chronic illnesses that are associated with significant healthcare needs and labor costs (19, 20). Financially, high body mass index causes 2% to 7% of global healthcare expenditure, and it seems clear that rising obesity levels will cause OA to soar unless a radical approach is taken to control obesity (21). Ackerman strongly upheld this latter report, and Niu and Zhang (22, 23) concluded that obesity is significantly associated with hip and knee OA.

Recognizing the significance of obesity and its related health problems will assist in the prevention of chronic ailments. Therefore, due to the multi-factorial links between obesity and OA and its comorbidities, the current research plans to determine the relationship between body mass index and hip OA among a group of patients in Hospital Universiti Sains Malaysia (HUSM).

MATERIALS AND METHODS

Participants. The participant sample comprised 70 patients who reported joint pain or problems in the hip region, drawn from the total population of patients consulting in the surgical units of the Hospital Universiti Sains Malaysia HUSM. The convenience sampling method was

employed in participant selection, with all those who met the inclusion criteria being approached to participate in the research. The respondents comprised 30 male (42.9%) and 40 female (57.1%) patients with a mean age of 53.2 (SD 7.1) years. The participating population mainly came from three ethnicities, namely Malay (74%), Chinese (10%), and Indian (13%), with others making up 3%. However, all were Malaysian in terms of their nationality. All respondents voluntarily consented to be included in the study and understood that they could opt-out at any time should they decide to discontinue their participation in the research. The study conformed with the institution's ethics guidance and followed the Declaration of the Helsinki Code.

Inclusion Criteria. Patients aged between 18 and 80 with a BMI range between 18.5 and ≥30.0 kg/m^2.

Exclusion Criteria. Extreme patient age was defined as <18 and >80 years old. Patients with an estimated BMI <18.5 kg/m^2 and patients who had already received bariatric treatment or arthroplasty surgery were also excluded from the research.

Data collection. The research was carried out following the Declaration of Helsinki guide, but before conducting the study, approval was obtained from the institution's Research Ethics Committee (USM/JePEM/18120810). Data were obtained from patients consulting in the surgery unit. This prospective cross-sectional study employed two forms of self-administered questionnaire: a 12-item osteoarthritis-associated perception questionnaire and the Western Ontario and McMaster Universities (WOMAC) Osteoarthritis Index. Before handing out the questionnaires to the patients, they were given a thorough explanation of the research, and after their participant consent was obtained, the questionnaires were administered to them.

For transparency in the data collation procedure, the self-administered questionnaires were coded before being handed to the patients to reduce bias and loss or duplication of data. Following Grotle and Hagen's (24) advice to ensure questionnaires are not time-consuming, we ensured each questionnaire could be completed in approximately 10 to 15 minutes since shorter durations will reduce interviewer and respondent bias. Ninety-four completed osteoarthritis perception questionnaires were obtained, but only 70 participants responded to all the items. Hence, a final total of 70 questionnaires with no missing data was used in the study.

Questionnaires Employed. Numerous medical tools can be utilized to evaluate patients with hip osteoarthritis (HOA). The three most pertinent and peculiar features of OA, i.e., pain, stiffness, and reduced physical function around the joint, were evaluated using a self-administered 12-item arthritis perception questionnaire and the 24-item Western Ontario and McMaster Universities (WOMAC) Osteoarthritis Index questionnaire for patients with joint complaints. Both indices are widely used disease-specific tools for assessing patients with arthritis, and both assess joint problems for pain, stiffness, and physical function around the involved joint (the hip joint in this study).

12-Item Perception Questionnaire Assessment of Hip Osteoarthritis. Obesity has a complex biomechanical pathway that causes articular cartilage degradation; up to now, its exact mechanism remains uncertain. Although mechanical, humoral, and genetic factors have been recorded as the most common causes (25), a considerable difficulty in arthritis diagnosis is still the complexity of detecting features to identify the initial stages of OA because the presentation only becomes evident when the condition is relatively advanced. By this time, it is likely to be irreversible. Although there are no good enough reference standards or benchmarks for diagnosing OA, a comprehensive appraisal and analysis can ensure a confident rule-in diagnosis if the following particular joint-related presentations appear:

1. Three particular features (constant hip joint pain, reduced daylight stiffness/rigidity, and diminished joint function) and three signs (crepitus, limited joint movement, and bony-joint swelling) (26-28).

2. Osteoarthritis is clinically detected if 1, 2, 3, 4 or 1, 2, 5 or 1, 4, 5 of the following are identified: 1. Hip joint pain for most days in the preceding month; 2. crepitus and impaired articular joint movement;

3. Morning rigidity/stiffness continuing for 30 minutes or less;

4. Age 38 years or older; 5. Bony enlargement in the form of swell in the hip joint on examination (28, 29).

Following the definition for OA diagnosis, assessment of hip joint OA status entails three

main domains aside from the patient's age: persistent hip joint pain, joint rigidity/stiffness, and restricted physical function and mobility. The 12-item questionnaire contains osteoarthritis-related questions that evaluate hip pain (Q1, Q2, Q3, Q10, Q12), joint stiffness and reduced function (Q4, Q5, Q6), and reduced mobility (Q7, Q8, Q9, Q11). Each question has 5 options to choose from when the patients are answering the questionnaires, using a 5-point Likert scale with answer options designated "None," "Very mild," "Mild," "Moderate," and "Severe." Because of the lack of a diagnostic cut-off point, we derived cut-off scores from the question's five answer choices. The first three answer choices, denoted "None," "Mild," and "Very mild," were regarded as not indicating arthritis ("No osteoarthritis"). In contrast, the final two answer choices, denoted "Moderate" and "Severe," states were regarded as indicating arthritis ("Yes osteoarthritis"). The questionnaire yielded a maximum total score of 60; a score of <36 were categorized as "No osteoarthritis," while a score of >36 was identified as "Yes osteoarthritis".

Internal consistency of the scores of the participant sample based on Cronbach's Alpha. Dawson created the 12-item osteoarthritis-evaluating questionnaire to assess patients' pre-operation perceptions of joint challenges (30). Still, it has undergone a series of updates and reviews since its creation. As described above, patients are directed to answer each item using a 5-point Likert scale, and each item is assigned a score of 1 to 5, from the least to the most severe condition. The combined score generates a single score ranging from 12 (slightest difficulty condition) to 60 (most challenging condition). The questionnaire's reliability was examined after it had been translated into the Malay language. The results for reliability are shown in Table 1 below. According to Cronbach's alpha, the internal consistency for the items assessing joint pain, stiffness, and reduced function were reported to be 0.853, 0.877, and 0.886, respectively.

Table 1. Summary of internal consistency of the HOA patients based on Cronbach's alpha reliability

Sub-scale	Number of items	Mean	Cronbach's alpha	Total-item correlation
Pain	5	2.31	0.853	0.635-0.786
Stiffness	3	1.76	0.877	0.777-0.872
Mobility	4	1.89	0.886	0.681-0.707

Cronbach's alpha (α) of $0.8<\alpha<0.9$ indicates good internal consistency.

Western Ontario and McMaster Universities (WOMAC) Osteoarthritis Index Questionnaire. The WOMAC questionnaire used in this study comprises 24 items with answer choices on a five-point Likert scale, with responses corresponding to "None (0)," "Mild (1)," "Moderate (2)," "Severe (3)," and "Extreme (4)." It has three domains investigating features of hip joint injuries and problems: 5 items, 2 items, and 17 items that assess joint pain, rigidity/stiffness, and physical function state, respectively (see Table 2 below). WOMAC is generally accepted as a valid and reliable health tool that assesses pain, stiffness, and physical function in patients with arthritis-related problems.

A detailed explanation was given to the patients to ensure they had read and understood the items before answering them. The aggregate values for pain, stiffness, and function were added to get the overall WOMAC score, which was then graded from 0 to 100, with 0 denoting the best medical status and 100 the worst probable status. The higher the aggregated score, the more the pain, stiffness, and disability, i.e., the lower the function. The reliability of the WOMAC questionnaire in patients with HOA is exceptional, with a documented internal consistency of between 0.81 and 0.93 (31).

Statistical Analysis. The study data were analyzed using descriptive statistics to illustrate demographic variables such as frequency, percentage, mean, and standard deviation. In contrast, inferential analysis (using Pearson chi-square and independent t-tests) was employed to determine the relationship between obesity and the likelihood of hip osteoarthritis for both questionnaire investigations. BMI was categorized into two groups: non-obese 18–29.9 kg/m^2 and obese >30 kg/m^2. Categorical data were reported as percentages, and differences were analyzed using t-tests for the 12-item questionnaire. The data collected for the dependent variables (WOMAC measures for pain, stiffness, and

physical function) and the independent variable (BMI group) were investigated using Pearson chi-square tests. The association was considered significant at p-value <0.05. The data were vetted and cleansed before the final analysis to ensure all data were accurately recorded in the datasheet to certify the thoroughness and completeness of the data. Each item's minimum and maximum range were ensured to ascertain that the values fell within the correct response range.

Table 2. WOMAC questionnaire characteristics

	Items	None 1	Mild 2	Moderate 3	Severe 4	Extreme 5
WOMAC-Pain	**Amount of pain felt in your hip over the last 48 hours** 1. Walking on a flat surface 2. Climbing up and down the staircase 3. At night, while in bed, pain disturbs your sleep 4. Sitting or lying 5. Standing upright					
WOMAC-Stiffness	**Amount of stiffness felt in your hip over the last 48 hours** 6. How severe is your stiffness after your first awakening in the morning? 7. How severe is your stiffness after sitting, lying, or resting during the day?					
WOMAC-Physical function	**Amount of difficulty of physical activities felt in your hip over the last 48 hours** 8. Descending stairs 9. Ascending stairs 10. Rising from sitting 11. Standing 12. Bending to the floor 13. Walking on flat surfaces 14. Getting in and out of a car or on and off a bus 15. Going shopping 16. Putting on your socks or stockings 17. Rising from the bed 18. Taking off your socks or stockings 19. Lying in bed 20. Getting in and out of the bath 21. Sitting 22. Getting on and off the toilet 23. Performance of heavy domestic duties 24. Performance of light domestic duties					

Items on the questionnaire use responses from the following lists:
1= None, No days, Not at all, No trouble at all, No pain, Yes easily, No nights, Rarely, No pain >30 minutes.
2= Very mild, Only 1–2 days, A little bit, Minimal trouble/difficulty, 16–30 minutes, Slightly painful, Only 1–2 nights, Sometimes/just at first.
3= Mild, Some days, Moderately, Moderate trouble, Moderate difficulty, 5–15 minutes, Moderately painful, Some nights.
4= Moderate, Most days, Greatly, Extremely difficult, Around the house, Very painful, Most nights.
5= Severe, Every day, Totally, Impossible to do, No, Impossible, Unbearable, All the time, Every night.
Interpretation: 1= None, 2= Very mild, 3= Mild, 4= Moderate, 5= Severe.

RESULTS

Demographic of BMI and 12-item arthritis assessment questionnaire scores. Data from a total of 70 patients were evaluated. Descriptive statistics for the dependent and independent variables for the descriptive means of the participants' heights, weights, and BMI scores (Table 3) and demographic data for the patients in the two BMI categories (non-obese and obese) are presented in Table 4. The assessment includes demographic characteristics (e.g., age, gender, ethnicity), BMI group, and characteristics drawn from the questionnaire assessment of hip osteoarthritis. The overall mean (SD) for age was 53.2 (7.1) years, and was 55.24 (17.251) for females, 66.86 (12.090) kg for weight, and 31.09 (6.514) kg/m^2 for BMI.

Table 4 below illustrates the demographic characteristics of the patients. From the total of 70 patients who were recruited for this research, females accounted for 57.1% of the total population. The female-to-male ratio was 14

(45.7%) to 16 (53.3%) in the non-obese group and 26 (65.0%) to 14 (35.0%) in the obese group, respectively, with all participants falling in the age range between 18 and 80 years.

Table 3. Descriptive statistics means and standard deviations for dependent and independent variables, n=70

Variables	Mean (SD)
Age (years)	53.2 (7.1)
Females	55.24 (17.251)
Height (m)	1.67 (0.087)
Weight (kg)	66.86 (12.090)
BMI (kg/m^2)	31.09 (6.514)

The occupation status of the participants was categorized as either "Employed" or "Unemployed," with 12 employed (40.0%) and 18 unemployed (60.0%) in the non-obese group and 21 employed (52.5%), and 19 unemployed (47.5%) in the obese group. In terms of ethnicity, ethnic Malays were in the majority, making up 20 (71.8%) and 32 (80.0%) of the patients in the non-obese and obese groups, respectively, and accounting for three-fourths of the whole participant sample (N=70). They were followed by ethnic Indians, of whom there were 3 (10.3%) in the non-obese group and 6 (15.0%) in the obese group respectively. Ethnic Chinese were the least common, with 5 patients (15.4%) in the non-obese group and 2 patients (5.0%) in the obese group. In terms of their chronic disease status, patients who reported two comorbid diseases were the most common at 50% vs. 25% among the non-obese and obese groups, respectively, while patients reporting more than four disease types were the least common at 0% vs. 3.5% in the non-obese and obese respectively.

Table 4. Demographic characteristics of patients (N=70)

Variables	Non-obese n (%)	Obese n (%)	X (df)	p-value
Gender			2.7 (1)	0.021
Male	16 (53.3)	14 (35.0)		
Female	14 (46.7)	26 (65.0)		
Age group			6.1 (5)	0.031*
18–29	0 (0.00)	3 (7.5)		
30–39	4 (13.3)	5 (12.5)		
40–49	7 (23.3)	5 (12.5)		
50–59	7 (23.3)	10 (25.0)		
60–69	8 (26.7)	15 (37.5)		
70–79	4 (10.0)	2 (5.0)		
Ethnicity			3.2 (3)	0.050*
Malay	20 (71.8)	32 (80.0)		
Chinese	5 (15.4)	2 (5.0)		
Indian	3 (10.3)	6 (15.0)		
Other	2 (2.6)	0 (0.0)		
Job-status			0.8 (1)	0.061
Employed	12 (40.0)	21 (52.5)		
Unemployed/retiree	18 (60.0)	19 (47.5)		
Number of comorbid diseases			5.4 (4)	0.023*
0	6 (20.0)	9 (22.5)		
1	7 (23.3)	13 (32.5)		
2	15 (50.0)	10 (25.0)		
3	2 (6.7)	5 (12.5)		
>4	0 (0.0)	3 (7.5)		

*: Fisher exact test.

12-Item Questionnaire Assessment of Hip Osteoarthritis (HOA). Table 5 below shows the patients' responses concerning their perception of the state of their HOA, collected via the self-administered 12-item questionnaire. This part of the investigation aimed to determine the occurrence and severity of HOA among the 70 patients in our participant group to identify the

proportion of patients likely to have developed obesity-related HOA.

Each questionnaire item was answered via a 5-option Likert scale with answer options labeled "None," "Very mild," "Mild," "Moderate," and "Severe." QZ-1 asked about the "level of pain experienced by the patient," and just over a third reported "Mild" or "Very mild" pain (11 patients (15.7%) and 15 patients (21.4%) respectively). In comparison, 21 patients (30.0%) reported "Moderate" pain and 6 patients (8.6%) reported "Severe" pain. The remaining 17 patients (24.2%) reported "No pain." QZ-2 and QZ-3 assessed "pain at rest (non-active)" and "pain interference with daily activity," respectively. In response to QZ-2, the majority, 45 patients (64.3%), they were reported "None," implying no pain when they were not moving, and only 2 patients (2.9%) reported "Severe" pain at rest. For QZ-3, most reported "Very mild" pain during daily activity, amounting to 25 patients (35.7%), although a few (3 patients, 4.3%) reported "Severe" difficulties.

Table 5. Summary of characteristics of 12-item questionnaire assessment of hip osteoarthritis (N=70)

	Item	Score 1 n (%)	2 n (%)	3 n (%)	4 n (%)	5 n (%)
Q1	Usual level of pain from hip	17 (24,2)	15 (21.4)	11 (15.7)	21 (30.0)	6 (8.6)
Q2	Pain from your hip at rest (non-activity)	45 (64.3)	14 (20.0)	6 (8.6)	3 (4.3)	2 (2.9)
Q3	Daily living activity interference due to hip pain	20 (28.6)	25 (35.7)	18 (34.3)	4 (5.7)	3 (4.3)
Q4	Trouble with washing and drying yourself due to hip pain	44 (62.9)	13 (18.6)	9 (12.9)	3 (4.3)	1 (1.4)
Q5	Trouble with getting in and out of car or public transport due to hip pain	34 (48.6)	20 (28.6)	14 (20.0)	1 (1.4)	1 (1.4)
Q6	Problems with putting on socks/stockings/tights due to hip pain	44 (62.9)	17 (24.3)	6 (8.6)	1 (1.4)	2 (2.9)
Q7	Difficulties doing household shopping alone due to hip pain	41 (58.6)	20 (28.6)	4 (5.7)	3 (4.3)	2 (2.9)
Q8	Walking time before stopping/resting due to pain from the hip	31 (44.3)	21 (30.0)	12 (17.1)	2 (2.9)	4 (5.7)
Q9	Difficulty climbing upstairs due to hip pain	21 (30.0)	24 (34.3)	16 (22.9)	6 (8.6)	3 (4.3)
Q10	Pain from standing up from sitting due to hip pain	30 (42.9)	26 (37.1)	9 (12.9)	4 (5.7)	1 (1.4)
Q11	Limping when walking due to hip pain	34 (48.6)	24 (34.3)	5 (7.1)	3 (4.3)	4 (5.7)
Q12	Pain from the hip wakes you in bed at night	52 (74.3)	10 (14.3)	3 (4.3)	3 (4.3)	2 (2.9)

1= None, No days, Not at all, No trouble at all, No pain, Yes easily, No nights, Rarely, No pain, >30 minutes.
2= Very mild, Only 1–2 days, A little bit, Minimal trouble/difficulty, 16–30 minutes, Slightly painful, Only 1–2 nights, Sometimes/just at first.
3= Mild, Some days, Moderately, Moderate trouble, Moderate difficulty, 5–15 minutes, Moderately painful, Some nights.
4= Moderate, Most days, Greatly, Extremely difficult, Around the house, Very painful, Most nights.
5= Severe, Every day, Totally, Impossible to do, No, impossible, Unbearable, All the time, Every night.
Interpretation: 1= None, 2= Very mild, 3= Mild, 4= Moderate, 5= Severe.

QZ-4, QZ-5, and QZ-6 assess the "degree of stiffness because of pain from the hip." Here, while the majority of answers to QZ-4, QZ-5, and QZ-6 reported "None" (62.9%, 48.6%, and 62.9%, corresponding to 44, 34 and 44 patients respectively), a few reported "Severe difficulty" as follows: 1 patient (1.4%) each for QZ-4 and QZ-5 respectively, and 2 patients (2.9%) for QZ-6.

QZ-7, QZ-8, QZ-9, and QZ-11 assess "movement difficulty because of pain from the hip," appraised it in terms of more vigorous activities (energy-challenging mobile activities) such as carrying out household/domestic shopping, walking distance before stopping, climbing the stairs, and limping while walking. A majority reported "No pain" (no difficulty) for QZ-7 and QZ-8 (41 patients (58.6%) and 31 patients (44.3%) respectively), while a similar majority reported "Very mild" pain (or little difficulty climbing stairs) in response to QZ-9 (24 patients, 34.3%). Also, concerning QZ-7, QZ-8, and QZ-9, "Moderate difficulty" was reported by 3 patients (4.3%), 2 patients (2.9%), and 6 patients (8.6%), respectively, while "Severe difficulty" of movement was reported by 2 patient (2.9%), 4 patients (5.7%), and 3 patients (4.3%) respectively. In response to QZ-10, which also evaluates the nature, the majority (30 patients, 42.9%) reported "No pain" (no escalating difficulties), while only 1 patient (1.4%) reported "Severe" escalating difficulties.

Finally, QZ-11 and QZ-12 assess the severity of the respondents' osteoarthritis: QZ-11 asks about "limping when walking," and QZ-12 asks whether "pain wakes you up in bed at night" due to osteoarthritis in the hip joint. Here, the majority reported "None" (no limping or no waking from sleep; 34 patients (48.6%) and 52 patients (74.3%) for QZ-11 and QZ-12, respectively). Further, concerning QZ-11, 3 patients (4.3%) reported "Moderate pain" (limping most of the time), but there was no report of "Severe pain" (limping all the time). For QZ-12, 3 patients (4.3%) reported: "Moderate pain" in bed at night (woken by pain most nights), while only 2 patients (2.9%) reported "Severe pain" (woken by pain every night).

Body Mass Index (BMI) Groups. Table 6 below shows the proportions of the BMI groups with and without HOA. The results indicate that among the group without HOA (the NO-HOA group), 28 patients (49.1%) were non-obese, while 29 patients (50.9%) were obese. Meanwhile, among the group with HOA (the YES-HOA group), 2 patients (15.4%) were non-obese, while 11 patients (84.6%) were obese. Also, we observed that the proportion of patients with HOA was greater among the obese group (84.6%) than in the non-obese group (15.4%). The overall proportion of obese to non-obese in the YES-HOA group was 5:1, suggesting that the likelihood of having HOA is five times greater among obese patients.

Table 6. Summary description of characteristics of the BMI groups with and without hip osteoarthritis (N=70)

Variables	Non-obese n (%)	Obese n (%)	X (df)	P-value
Hip Osteoarthritis (HOA)			3.1 (1)	0.0001*
NO-HOA	28 (49.1)	29 (50.9)		
YES-HOA	2 (15.4)	11 (84.6)		

*: Fisher exact test.

Analysis of BMI-related Susceptibility to Hip Osteoarthritis (HOA). Table 7 below illustrates the analysis investigating the relationship between BMI-related susceptibility to HOA among the patients recruited at Hospital USM. The results indicate a highly significant mean difference (p-value =0.001) in BMI between the HOA groups. The mean BMI of patients in the YES-HOA group (42.14, SD 3.24) was more significant than the mean BMI of patients in the NO-HOA group (30.95, SD 0.51). This suggests that HOA risk is significantly related to the patient's body mass, and there is no doubt that being overweight is a significant risk factor for HOA.

Table 7. Independent t-test to determine the relationship between BMI-related susceptibility to hip osteoarthritis among patients visiting Hospital USM

Hip Osteoarthritis	Mean BMI (SD)	t (df)	p-value
No	30.95 (0.51)	-3.69 (69)	0.001
Yes	42.14 (3.24)		

Analysis of WOMAC Assessment of BMI-related Susceptibility to Hip Osteoarthritis (HOA). Table 8 below shows the data obtained from 70 patients with HOA, assessed via the 24-item WOMAC questionnaire. The overall response rate was 100%. For the three OA features assessed by WOMAC, "None" and "Mild" were the most common responses: 38.6% and 24.3% for pain, 34.3% and 28.6% for stiffness, and 30.9% and 22.1% for reduced function, respectively. In terms of the level of severity of these three OA features, "Reduced function" was the most commonly reported, while "Severe" and "Extreme" combined for each feature were reported at 21.5% for pain, 22.8% for stiffness, and 25.7% for reduced function respectively.

Further, in terms of our analysis of the susceptibility of BMI groups to HOA, the results showed that obese individuals returned significantly higher WOMAC scores mean than the non-obese group: non-obese-to-obese ratios were 45 (SD 13) to 58 (SD 17) for pain, 54 (SD 19) to 61 (SD 20) for stiffness, and 51 (SD 11) to 71 (SD 24) for reduced function. Overall, the WOMAC mean score ratio between the non-obese and obese groups was 52 (SD 21) to 64 (SD 22) respectively (p-value <0.05). In general, the non-obese group reported better general health status

compared to the obese group. There was a difference of approximately 12.0% between the mean WOMAC scores from the two BMI groups, indicating that weight reduction could be a significant non-invasive therapy approach to controlling OA.

Table 8. Outline of characteristics of WOMAC questionnaire evaluation of hip osteoarthritis (N=70)

WOMAC Subscale	None n (%) 1	Mild n (%) 2	Moderate n (%) 3	Severe n (%) 4	Extreme n (%) 5
WOMAC Pain	27 (38.6)	17 (24.3)	11 (15.7)	9 (12.9)	6 (8.6)
WOMAC Stiffness	24 (34.3)	20 (28.6)	10 (14.3)	9 (12.8)	7 (10.0)
WOMAC Physical Function	21 (30.0)	16 (22.9)	15 (21.4)	10 (14.2)	8 (11.4)

WOMAC Subscale	Non-obese mean (SD)	Obese mean (SD)	P-values
WOMAC Pain	45+13	58+17	0.05
WOMAC Stiffness	54+19	61+20	0.001
WOMAC Physical Function	51+11	71+24	0.05
WOMAC Overall	52+21	64+22	0.001

DISCUSSION

OA is a leading trigger of musculoskeletal pain and is regarded as an essential cause of disability and an impediment to joint function. It is, therefore, considered a particular burden for community healthcare. In our study, a 12.0% decrease in the overall mean WOMAC score between the non-obese and obese groups could be associated with the lower BMI of the non-obese group, representing the most critical research finding.

The association between rising levels of obesity around the globe and the prevalence of OA (the fourth most common cause of frailty), as suggested by Mahir and Belhaj (32), remains only partially understood (25). However, it is postulated to be multi-factorial, involving humoral, genetic, and mechanical factors. Previous work has confirmed forfeiture of the bony matrix dynamic due to mechanical insult (trauma) or overburden (obesity) on typical cartilaginous structures or to normal loading on abnormal cartilage (genetic defects and aging), all leading to joint bony property changes (abnormal biomechanics and misalignment) in the bone end trabeculae mesh network (33). The significance of high loading pressure on joint articulating surfaces in the HOA mechanism was illustrated in our study's findings since 84.6% of the obese patients fell into the YES-HOA category; Jiang, Xie (34) also reported the joint degradation model. The theories that emphasize this close relationship between obesity and the progression of HOA are coherent, with the condition being facilitated by several factors.

The increasing prevalence of overweight/obesity is a challenging subject worldwide, and frequent mass-media announcements designate OA as an illness of old age characterized by disabling effects that reduce the quality of life, especially in late adulthood. In our study's demographic findings, the mean age was 53.2 years, with the majority being in the 50–59 and 60-69 age brackets, indicating that most of our population was in late adulthood. Furthermore, females represented 57.1% of our sample. Global Health Observatory data released by the WHO in 2014 stated the prevalence of obesity at 15% in women and 11% in men aged 18 and above (9, 35). A lot of other studies have emphasized the growing incidence of arthritis (especially knee and hip OA) during recent decades, and it seems clear that this is concurrent with the accelerating obesity epidemic in the aging global population (13). Among 66% of our late adult age group population, 69.5% were obese. This explains the high overall mean WOMAC score of 64 (SD 22) for the obese group (p-value <0.05). Obesity leads to heightened loading on weight-bearing joints, a scenario that culminates in a negative mechanical effect on joint function; a study by Afolabi bin Zakariya (36) indicates that greater fat mass increases cartilage and bone marrow breakdown, and these are also early presentations of HOA.

Patients with HOA have a reduced range of motion in the hip (37). BMI reduction in HOA-affected individuals can reduce muscle stiffness and improve hip joint mechanical function (38, 39). Neumann, Guimaraes (40), and Nicholson

(41) noted that cushion tensile strength in the hip joint could be crucially disrupted by the loss of joint fluidity once the cartilage that cushions the joint bone deteriorates progressively when the cartilage's firm and slippery property that allows frictionless joint motion is lost. This ultimately leads to complete cartilaginous wear-down, allowing joint end bones to rub against each other and sensory nerve cells and producing the pain sensation in HOA (42).

The overall WOMAC score reported by the non-obese patient was significantly lower (by 12.0 points) than that reported by the obese group. Likewise, the mean of the YES-HOA group was higher [42.12 (SD 3.24)] than the mean of the NO-HOA group [30.95 (SD 0.51)] ($p<0.05$). This reveals a positive relationship between patient-reported OA status and obesity. The sum of the WOMAC score for HOA pain, stiffness, and reduced function between the groups was better in the non-obese than the obese group; non-obese vs. obese was 45 (SD 13) vs. 58 (SD 17) for WOMAC pain, 54 (SD 19) vs. 61 (SD 20) for WOMAC stiffness, and 51 (SD 11) vs. 71 (SD 24) for WOMAC mobility function ($p<0.05$). This confirms clinicians' observations and findings that obesity is strongly associated with chronic joint pain in the broad populace, and pain discomfort or complaints are more severe in obese patients (43).

The general hypothesis is that high BMI patients are susceptible to destruction of the subchondral layer of bone beneath the cartilage of the joint (44), particularly on the weight-reliant section of the joint (hip joint) because it causes the destruction of the hyaline cartilage-containing chondrocytes in the extracellular matrix of the joint. In addition, obesity is a clinically proven risk factor for several chronic disease conditions such as diabetes mellitus, heart disease, cancer, and arthritis (45, 46). Our study's result shows that obesity is crucially linked with the incidence and advancement of hip osteoarthritis since we found higher mean BMI scores and overall mean WOMAC scores for the obese group [42.12 (SD 3.24) and 64.0 (SD 22)] than the non-obese group [30.95 (SD 0.51) and 52.0 (SD 21)] respectively. A related outcome was reported by Jiang and Tian (47) and Manek and Hart (48), who found that obesity led to the breakdown and loss of the articular cartilage of the hip joint via the wear-and-tear effect, which was even more noticeable in the knee. Another research finding by Ackerman and Bohensky (49) and Pilz and Hanstein (50) suggests that the rise in OA is projected to be accompanied by a surge in joint replacement surgery if the incidence of obesity-related OA is not crucially addressed. The inflammatory association causes a decrease in the number of proteoglycans that enable water-binding capacity in the joint, thus leading to thinner, firmer cartilage with less resilience and greater vulnerability to injury. Hence, a higher BMI predisposition to hip osteoarthritis (HOA) subsequently increases the need for hip replacement surgery.

Our study has established high body mass index as a risk factor for HOA development. However, the study was not without limitations; these include recruiting participants from only one specific institution, limiting the possibility of multi-institution comparison. Also, there may have been a risk of understated or dishonest responses from the participants due to using a self-administered questionnaire, which biased responses can characterize. However, we believe this is not a significant threat to the reliability of the study because the patients were assured that their identities and responses would be blinded to all the researchers. This measure should help to prevent bias. All the participants were encouraged to answer honestly and genuinely to all the questionnaire items related to their understanding of their situation and not to seek views from elsewhere when filling in the questionnaires.

Based on our outcomes, we can confidently claim that obesity and joint pain from HOA are not merely shared medical concerns, but both illnesses co-occur. However, we acknowledge that other surveys investigating this association have presented conflicting outcomes, perhaps implying that the link between overweight/obesity and HOA features is not straightforward but may be facilitated by numerous conditions such as genetics and environmental influences.

CONCLUSION

The prevalence of obesity-related hip OA is increasing around the world, and the global rise in BMI is thought to be a significant contributory cause. This study clearly shows a relationship between both conditions. Since hip OA can now be seen as an avoidable side effect of obesity, a strict strategy for regulating obesity is strongly advised to stem the rising incidence of obesity and ultimately reduce the prevalence of hip OA throughout the world.

APPLICABLE REMARKS

- The study demonstrates a significant correlation between obesity and hip osteoarthritis (HOA). Obese patients, as defined by a BMI greater than 30, were found to have a substantially higher mean BMI and a greater prevalence of HOA compared to their non-obese counterparts. This suggests a higher body weight is a considerable risk factor for developing and progressing HOA.
- The findings highlight that females are more likely to be obese and consequently at higher risk for HOA, with the average age of participants being 53.2 years. This suggests that middle-aged to older adults, particularly women, are a crucial demographic for targeted interventions aimed at reducing obesity to mitigate the risk of HOA.
- The study found that obese patients had significantly higher WOMAC scores, indicating more severe pain, stiffness, and reduced function in the hip joints compared to non-obese patients. This underscores the importance of weight management in improving the quality of life for patients with HOA, as obesity exacerbates the symptoms and functional impairments associated with the condition.

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AUTHORS' CONTRIBUTIONS

Study concept and design: Hafeez Abiola Afolabi, Yusuf Wada, Sameer Badri Al-Mhanna. Data acquisition: Yusuf Wada, Omar Mahmoud Said Alshajrawi. Analysis and interpretation of data: Hafeez Abiola Afolabi, Yusuf Wada, Sameer Badri Al-Mhanna. Drafting the manuscript: Hafeez Abiola Afolabi, Zaidi Zakaria, Yuni Astuti, Omar Mahmoud Said Alshajrawi. Critical revision of the manuscript for important intellectual content: Hafeez Abiola Afolabi, Zaidi Zakaria, Yuni Astuti, Salzihan Md Salleh, Nouf H. Alkhamees, Yusuf Wada, Dauda Goni Mohammed, Omar Mahmoud Said Alshajrawi, Sameer Badri Al-Mhanna. Statistical analysis: Hafeez Abiola Afolabi, Omar Mahmoud Said Alshajrawi, Sameer Badri Al-Mhanna. Administrative, technical, and material support: Hafeez Abiola Afolabi, Dauda Goni Mohammed. Study supervision: Zaidi Zakaria, Salzihan Md Salleh.

CONFLICT OF INTEREST

The authors reported no potential conflict of interest.

ETHICAL CONSIDERATION

The research was carried out following the Declaration of Helsinki guide, but before conducting the study, approval was obtained from the institution's Research Ethics Committee (USM/JePEM/18120810).

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ROLE OF THE SPONSOR

The sponsor had no role in the study design, data collection, data analysis, interpretation of results, manuscript preparation, or decision to submit the article for publication.

FINANCIAL DISCLOSURE

The authors declare that they have no financial interests or relationships that could influence the content or outcomes of this study. No financial conflicts of interest are associated with this research.

ARTIFICIAL INTELLIGENCE (AI) USE

Artificial intelligence tools were not utilized in this manuscript's conceptualization, data analysis, or writing, except for general-purpose language models used for proofreading or editing assistance, where applicable.

REFERENCES

1. Al-Mhanna SB, Mohamed M, Mohd Noor N, Aldhahi MI, Afolabi HA, Mutalub YB, et al. Effects of Circuit Training on Patients with Knee Osteoarthritis: A Systematic Review and Meta-Analysis. Healthcare (Basel). 2022;10(10). [doi:10.3390/healthcare10102041] [PMid:36292488]

2. Coleman, R.M., Engineering closed-loop, autoregulatory gene circuits for osteoarthritis cell-based therapies. Current Rheumatology Reports. 2022;24(4):96-110. [doi:10.1007/s11926-022-01061-x] [PMid:35404006]
3. Yang, Y., et al., Obesity or increased body mass index and the risk of severe outcomes in patients with COVID-19: a protocol for systematic review and meta-analysis. Medicine. 2022;101(1):e28499. [doi:10.1097/MD.0000000000028499] [PMid:35029905]
4. Al-Mhanna, S.B., et al., Effects of combined aerobic exercise and diet on cardiometabolic health in patients with obesity and type 2 diabetes: a systematic review and meta-analysis. BMC Sports Sci Med Rehabil. 2023;15(1):165. [doi:10.1186/s13102-023-00766-5] [PMid:38049873]
5. Anyabolu, E., Anaemia and its associated factors in patients attending a General Out-Patient Clinic in a tertiary hospital in Southeast Nigeria. International Journal of Medical and Biomedical Research. 2017;6(1):10-17. [doi:10.14194/ijmbr.6.1.2]
6. Agofure, O., Prevalence of obesity among adults in issele-uku, Delta state Nigeria. Alexandria journal of medicine. 2018;54(4):463-468. [doi:10.1016/j.ajme.2017.10.005]
7. Shin, S.H., et al., Association of body mass index and COPD exacerbation among patients with chronic bronchitis. Respiratory Research. 2022;23(1):52. [doi:10.1186/s12931-022-01957-3] [PMid:35255901]
8. Kêkê, L., et al., Body mass index and childhood obesity classification systems: A comparison of the French, International Obesity Task Force (IOTF) and World Health Organization (WHO) references. Revue d'epidemiologie et de sante publique. 2015;63(3):173-182. [doi:10.1016/j.respe.2014.11.003] [PMid:26002984]
9. Fan, J.-G., S.-U. Kim, and V.W.-S. Wong, New trends on obesity and NAFLD in Asia. Journal of hepatology. 2017;67(4):862-873. [doi:10.1016/j.jhep.2017.06.003] [PMid:28642059]
10. Mutalub, Y.B., et al., Gut Microbiota Modulation as a Novel Therapeutic Strategy in Cardiometabolic Diseases. Foods. 2022;11(17). [doi:10.3390/foods11172575] [PMid:36076760]
11. Ritchie, H., F. Spooner, and M. Roser, Causes of death. Our world in data. 2018.
12. Zhang, Y., et al., Exploration of the typical features of tubulovillous adenoma using in-depth quantitative proteomics analysis. Bioengineered. 2021;12(1):6831-6843. [doi:10.1080/21655979.2021.1971036] [PMid:34585630]
13. Ackerman, I.N., et al., The substantial personal burden experienced by younger people with hip or knee osteoarthritis. Osteoarthritis and Cartilage. 2015;23(8):1276-1284. [doi:10.1016/j.joca.2015.04.008] [PMid:25887363]
14. Ilia, I., D. Nitusca, and C. Marian, Adiponectin in Osteoarthritis: Pathophysiology, Relationship with Obesity and Presumptive Diagnostic Biomarker Potential. Diagnostics. 2022;12(2):455. [doi:10.3390/diagnostics12020455] [PMid:35204546]
15. Nedunchezhiyan, U., et al., obesity, inflammation, and immune system in osteoarthritis. Frontiers in immunology. 2022;13:907750. [doi:10.3389/fimmu.2022.907750] [PMid:35860250]
16. Hawker, G.A. and L.K. King, The burden of osteoarthritis in older adults. Clinics in Geriatric Medicine. 2022;38(2):181-192. [doi:10.1016/j.cger.2021.11.005] [PMid:35410675]
17. Jiang, L., et al., Body mass index and hand osteoarthritis susceptibility: an updated meta-analysis. Int J Rheum Dis. 2016;19(12):1244-1254. [doi:10.1111/1756-185X.12895] [PMid:28371440]
18. Wang, T. and C. He, Pro-inflammatory cytokines: The link between obesity and osteoarthritis. Cytokine & growth factor reviews. 2018;44:38-50. [doi:10.1016/j.cytogfr.2018.10.002] [PMid:30340925]
19. Busetto, L., P. Sbraccia, and R. Vettor, Obesity management: at the forefront against disease stigma and therapeutic inertia. Eating and Weight Disorders-Studies on Anorexia, Bulimia and Obesity. 2022;27(2):761-768. [doi:10.1007/s40519-021-01217-1] [PMid:34052990]
20. Al-Mhanna, S.B., et al., Effectiveness of physical activity on immunity markers and quality of life in cancer patient: a systematic review. PeerJ. 2022;10:e13664. [doi:10.7717/peerj.13664] [PMid:35935260]
21. Leifer, V.P., J.N. Katz, and E. Losina, The burden of OA-health services and economics. Osteoarthritis and cartilage. 2022;30(1):10-16. [doi:10.1016/j.joca.2021.05.007] [PMid:34023527]
22. Ackerman, I.N., R. Buchbinder, and L. March, Global Burden of Disease Study 2019: an opportunity to understand the growing prevalence and impact of hip, knee, hand and other osteoarthritis in Australia. Internal medicine journal. 2023;53(10):1875-1882. [doi:10.1111/imj.15933] [PMid:36114616]

23. Niu, J., et al., Is obesity a risk factor for progressive radiographic knee osteoarthritis? Arthritis Care & Research. 2009;61(3):329-335. [doi:10.1002/art.24337] [PMid:19248122]
24. Grotle, M., et al., obesity and osteoarthritis in knee, hip and/or hand: an epidemiological study in the general population with 10 years follow-up. BMC musculoskeletal disorders. 2008;9:1-5. [doi:10.1186/1471-2474-9-132] [PMid:18831740]
25. Sridhar, M., et al., obesity and symptomatic osteoarthritis of the knee. The Journal of Bone & Joint Surgery British Volume. 2012;94(4):433-440. [doi:10.1302/0301-620X.94B4.27648] [PMid:22434455]
26. Hunter, D., et al., Definition of osteoarthritis on MRI: results of a Delphi exercise. Osteoarthritis and cartilage. 2011;19(8):963-969. [doi:10.1016/j.joca.2011.04.017] [PMid:21620986]
27. Vahedifar M. Temporomandibular joint clinical considerations for practice. Lulu. com; 2015 July 22.
28. Khan, H.I., et al., History of knee injury and MRI-assessed knee structures in middle-and older-aged adults: a cross-sectional study. Clinical rheumatology. 2015;34:1463-1472. [doi:10.1007/s10067-014-2758-0] [PMid:25119865]
29. Bijlsma, J.W., F. Berenbaum, and F.P. Lafeber, Osteoarthritis: an update with relevance for clinical practice. The Lancet. 2011;377(9783):2115-2126. [doi:10.1016/S0140-6736(11)60243-2] [PMid:21684382]
30. Dawson, J., et al., questionnaire on the perceptions of patients about total knee replacement. The Journal of Bone & Joint Surgery British Volume. 1998;80(1):63-69. [doi:10.1302/0301-620X.80B1.0800063]
31. Arab, F., et al., Association of eccentric quadriceps torque with pain, physical function, and extension lag in women with grade≤ II knee osteoarthritis: An observational study. Medicine. 2022;101(31):e29923. [doi:10.1097/MD.0000000000029923] [PMid:35945742]
32. Mahir, L., et al., impact of knee osteoarthritis on the quality of life. Annals of physical and rehabilitation medicine. 2016;59:e159. [doi:10.1016/j.rehab.2016.07.355]
33. Wang, Z., et al., Instructive cartilage regeneration modalities with advanced therapeutic implantations under abnormal conditions. Bioactive Materials. 2022;11:317-338. [doi:10.1016/j.bioactmat.2021.10.002] [PMid:34977434]
34. Jiang, L., et al., Body mass index and hand osteoarthritis susceptibility: an updated meta-analysis. International Journal of rheumatic diseases. 2016;19(12):1244-1254. [doi:10.1111/1756-185X.12895] [PMid:28371440]
35. Marks, R., Post COVID communitybased self-care management of disabling osteoarthritis: importance and possible targeted needs. Int Phys Med Rehab J. 2022;7(3):106-111. [doi:10.15406/ipmrj.2022.07.00314]
36. Afolabi, HA, et al., The relationship between obesity and other medical comorbidities. Obesity Medicine. 2020;17:100164. [doi:10.1016/j.obmed.2019.100164]
37. Yılmaz, N. and F. Bağcıer, The evaluation of postural stability and fall risk in patients with primary hip osteoarthritis. Indian journal of orthopaedics. 2022;1-8.
38. Garcia, W.J., et al., The addition of body weight supported treadmill training to manual therapy and exercise in the management of Hip osteoarthritis: A case series. Physiotherapy Theory and Practice. 2024;40(2):408-417. [doi:10.1080/09593985.2022.2115329] [PMid:36036381]
39. Barati, K., et al., effect of equipping an unloader knee orthosis with vibrators on pain, function, stiffness, and knee adduction moment in people with knee osteoarthritis: A pilot randomized trial. Gait & Posture. 2023;99:83-89. [doi:10.1016/j.gaitpost.2022.10.019] [PMid:36368240]
40. Neumann, J., et al., Diabetics show accelerated progression of knee cartilage and meniscal lesions: data from the osteoarthritis initiative. Skeletal radiology. 2019;48:919-930. [doi:10.1007/s00256-018-3088-0] [PMid:30357451]
41. Nicholson JW. The chemistry of medical and dental materials. Royal Society of Chemistry; 2020 May 28. [doi:10.1039/9781788016360]
42. Wang, T. and C. He, Pro-inflammatory cytokines: The link between obesity and osteoarthritis. Cytokine Growth Factor Rev. 2018;44:38-50. [doi:10.1016/j.cytogfr.2018.10.002] [PMid:30340925]
43. Ceballos-Laita, L., et al., comparison of dry needling and self-stretching in muscle extensibility, pain, stiffness, and physical function in hip osteoarthritis: A randomized controlled trial. Complement Ther Clin Pract. 2022;49:101667. [doi:10.1016/j.ctcp.2022.101667] [PMid:36152527]

44. Tran, A., et al., Review of Extraosseous Applications of Thermal Ablation in the Treatment of Moderate to Severe Large Joint Osteoarthritis. Semin Musculoskelet Radiol. 2021;25(6):745-755. [doi:10.1055/s-0041-1735474] [PMid:34937115]
45. Bays, HE, et al., Obesity Pillars Roundtable: Obesity and South Asians. Obes Pillars. 2022;1:100006. [doi:10.1016/j.obpill.2021.100006] [PMid:37990701]
46. Afolabi, HA, et al., A GNAS Gene Mutation's Independent Expression in the Growth of Colorectal Cancer: A Systematic Review and Meta-Analysis. Cancers (Basel). 2022;14(22). [doi:10.3390/cancers14225480] [PMid:36428574]
47. Jiang, L., et al., Body mass index and susceptibility to knee osteoarthritis: a systematic review and meta-analysis. Joint Bone Spine. 2012;79(3):291-7. [doi:10.1016/j.jbspin.2011.05.015] [PMid:21803633]
48. Manek, NJ, et al., The association of body mass index and osteoarthritis of the knee joint: an examination of genetic and environmental influences. Arthritis Rheum. 2003;48(4):1024-9. [doi:10.1002/art.10884] [PMid:12687544]
49. Ackerman, I.N., et al., The projected burden of primary total knee and hip replacement for osteoarthritis in Australia to the year 2030. BMC Musculoskelet Disord. 2019;20(1):90. [doi:10.1186/s12891-019-2411-9] [PMid:30797228]
50. Pilz, V., T. Hanstein, and R. Skripitz, Projections of primary hip arthroplasty in Germany until 2040. Acta Orthop. 2018;89(3):308-313. [doi:10.1080/17453674.2018.1446463] [PMid:29504824]