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Original Article

Radiographic evaluation and pain symptomatology of the knee in severely obese individuals – controlled transversal study☆

Glaucus Cajaty Martins[a,b,*], *Luiz Felippe Martins Filho*[a], *Andre Heringer Raposo*[a], *Raphael Barbosa Gamallo*[a], *Zarthur Menegazzi*[b], *Antônio Vítor de Abreu*[b]

[a] *Serviço de Ortopedia e Traumatologia, Hospital Federal de Ipanema, Rio de Janeiro, RJ, Brazil*

[b] *Departamento de Ortopedia e Traumatologia, Faculdade de Medicina, Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, RJ, Brazil*

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ABSTRACT

Objective: To evaluate the prevalence of pain and radiographic degenerative arthritis in a group of severe obese patients (body mass index [BMI] > 35).

Methods: 41 patients with an indication of bariatric surgery were studied. The group of severely obese patients was subdivided into two subgroups: those with BMI < 50 and those with BMI > 50 ($n = 14$). They were compared to control group ($n = 39$). The following parameters were analyzed and correlated: radiographic arthritis by Kellgren-Lawrence's classification, tibiofemoral axis, gender, age, and knee pain (visual analog scale [VAS]). The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) was used to evaluate in 21 severe obese patients and IN 19 controls.

Results: A higher incidence of knee pain was observed in the severely obese group when compared with the control group ($p < 0.0001$, odds ratio: 2.96). In the severely obese group, increasing levels of pain with aging were observed ($p = 0.047$). A positive correlation was observed between the incidence of radiographic arthritis and increasing age in the severely obese ($p = 0.001$) and control ($p = 0.037$) groups. The WOMAC index results were worse in the severely obese group when compared with the control group ($p = 0.001$, odds ratio: 18.2).

Conclusion: A higher incidence of knee pain was observed in the severely obese group when compared with the control group. In the severely obese group, there increasing levels of pain with aging. A positive relation between the incidence of arthritis and increasing age was observed in the severely obese and control groups. The WOMAC index results were worse in the severely obese group.

☆ Study conducted at Hospital Federal de Ipanema, Rio de Janeiro, RJ, Brazil.

* *Corresponding author.*
E-mail: glaucusc@terra.com.br (G.C. Martins).

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Avaliação radiográfica e de sintomatologia dolorosa do joelho em indivíduos com obesidade grave – estudo controlado transversal

Palavras-chave:
Artrose
Joelho
Obesidade
Dor

RESUMO

Objetivo: Avaliar a prevalência de queixas álgicas no joelho e de alterações radiográficas degenerativas (artrose) em grupo obesos graves (índice de massa corporal [IMC] > 35).
Métodos: Foram avaliados 41 pacientes com obesidade grave acompanhados em ambulatório de cirurgia bariátrica. Esse grupo foi subdividido em dois: obesos com IMC < 50 (n = 27); e obesos com IMC > 50 (n = 14). Os resultados foram comparados com os do grupo controle (n = 39). Foram avaliados a presença de artrose radiológica pela classificação de Kellgren-Lawrence, eixo tibiofemoral, idade, gênero e dor no joelho pela escala visual (EVA), foi feita correlação dos parâmetros entre si. Em 21 pacientes obesos e em 19 controles foi avaliada com o índice das universidades Western Ontario e McMaster (Womac).
Resultados: Observou-se maior incidência de dor no grupo de obesos graves em relação ao grupo controle (p < 0,0001, coeficiente de risco de 2,96). No grupo de obesos graves observou-se aumento da dor com a idade (p = 0,047). Houve correlação positiva entre progressão da idade e artrose radiográfica tanto no grupo de obesos graves (p = 0,001) como no controle (p = 0,037). A escala Womac detectou pior desempenho funcional no grupo de obesos graves em relação ao controle (p = 0,0001, coeficiente de risco de 18,2).
Conclusão: Observou-se maior incidência de dor no grupo de obesos graves em relação ao controle. No grupo de obesos graves, a dor aumentou com a idade. Houve correlação positiva entre progressão da idade e artrose nos grupos de obesos graves e controle. O índice Womac apresentou pior desempenho no grupo de obesos graves.

Introduction

Obesity is one of the most challenging public health problems. Data from the United States show that 30% of adults over 20 years of age, around 60 million people, fall in the obesity range (BMI > 30) and 65 million (35%) in the overweight range[1] (BMI > 25). This entity also affects underdeveloped countries, where carbohydrate intake is highly widespread, as it is relatively cheap.[1]

Population studies have shown that obesity is an independent risk factor for the manifestation of knee arthrosis.[1–3] Coggon et al.[3] determined that individuals with severe obesity (body mass index [BMI] > 35 kg/m^2) had a 13.6-fold increased risk of developing gonarthrosis.

Classically, obesity could be related to degenerative joint conditions due to mechanical cartilage stress caused by increased local pressure. Currently, a new study branch has arisen, after the discovery of the proteins generated from visceral fat, the adipokines. The most known adipokine is leptin, which plays a role in insulin action and produces inflammatory cytokines in chondrocytes.[4] It is associated with systemic inflammatory processes, with effects in the coronary and carotid arteries and in joints such as the knee.[5] Recent clinical studies have shown a higher incidence of knee pain and arthrosis related to elevated serum adipokines and to metabolic syndrome (systemic hypertension, diabetes, and increased glucose, triglycerides, C-reactive protein, and LDL levels).[5]

The painful knee symptoms in obese patients are not due solely to the intra-articular and bony involvement determined by arthrosis.[6] More commonly and in an earlier stage, there are meniscal lesions, cartilage wear, and subchondral bone edema that generate pain and are usually not detected by conventional radiography, only by magnetic resonance imaging.[6–8] Other sources of pain are Hoffa's fat pad, patellar tendon, and pes anserinus.[9] Accurate knowledge of the type of lesion usually allows conservative or arthroscopic treatment in cases of soft tissue involvement, or the use of osteotomy or arthroplasty procedures when there is more significant bone involvement.[1]

In Medicine, epidemiological studies aim to identify specific groups in the population in which it is possible to detect increased levels of a particular disease and related factors. In this way, interventions can be designed in order to alter the course of a pathology and lessen its harmful effects.[10]

Few studies have addressed the involvement of the musculoskeletal system and its impact on individuals with morbid or severe obesity (BMI > 36).[3,10,11] Regarding the knee joint in this special subgroup of patients, the prevalence of pain, the degree of functional performance, alignment analysis, and the degree of radiographic involvement due to arthrosis have not yet been sufficiently described in the literature.[11] The compilation of these data is necessary for a proper assessment of the issue. The determination of clinical and imaging parameters that may indicate the need for early intervention plays a fundamental role in the formulation of therapeutic and, above all, preventive strategies in this growing group of individuals, who are most commonly of productive age.[10]

Table 1 – Concise parameters of the severely obese and control groups.

N		Control 39	Obese 41	BMI < 50 27	BMI > 50 14	Statistics Control X Obese	
	Age	42.1 ± 12.6	44.1 ± 10.1	48.3 ± 8.6	48.3 ± 12.0	NS	
	BMI	26.5 ± 3.2	48.7 ± 10.6	43.1 ± 5.1	59.5 ± 10.3	$p = 0.002$	
	Gender	14M:25F	11M:30F	6M:21F	5M:9F	NS	
	Angulation	2.8 ± 3.5	3.2 ± 2.9	3.2 ± 2.7	3.5 ± 3.4	NS	
Arthrosis (Kellgren)	Absent (0)	71.8%	53.7%	51.9%	57.1%	Kellgren	NS
	Discrete (I)	20.5%	17.1%	18.5%	14.3%		
	Mild (II)	0.0%	9.8%	11.1%	7.1%		
	Moderate (III)	5.1%	12.2%	14.8%	7.1%		
	Severe (IV)	2.6%	7.3%	3.7%	14.3%		

NS, not significant ($p > 0.05$).

The main objective of this study was to assess the relative prevalence of pain measured by visual analog scale (VAS) between a group of severely obese patients and a control group. Secondary objectives were to assess functional performance, measured by the Western Ontario and McMaster University (WOMAC) index and the correlation of pain (VAS) with the parameters of age, gender, radiographic arthrosis, and knee alignment between the study and control groups.

Material and methods

This cross-sectional study was approved by the research ethics committee of the hospital and followed the principles set forth by the Helsinki Convention.

The study included 41 patients who were admitted consecutively to the bariatric surgery outpatient clinic of this hospital from January 2014 to January 2015. The sample consisted of 11 males and 30 females, with an mean age of 44.1 years (SD: 10.1), who were subdivided into a subgroup of obese individuals with a BMI > 35 and <50 ($n = 27$) and another subgroup of superobese patients with BMI > 50 ($n = 14$).

A compatible gender- and age-matched control group, composed of volunteers (hospital employees), was created. The control group consisted of 39 individuals, 14 men and 25 women, with a mean age of 42.1 years (SD: 12.6; Table 1).

Inclusion criteria were individuals over 18 years of age who agreed to participate in the study. Individuals who had been submitted to surgical orthopedic, vascular, or dermatological-plastic procedures in any segment of the lower limbs were excluded. Individuals with sequelae of fractures in the lower limbs or pathologies with a surgical indication in the lower limbs (hip arthrosis or vascular pathologies) were also excluded. Patients who presented knee alterations discovered as a result of outpatient evaluation for the study, such as tendinitis or degenerative meniscal lesions, were not excluded.

BMI was calculated by dividing the weight in kg by the square of the height in meters, classified as BMI < 20 (underweight), 20–24.9 (normal), 25–29.9 (overweight), >30 (obese), >35 (morbidly obese), and >50 (superobese).[3,6]

The individuals surveyed were asked to report whether they had experienced knee pain in the last 48 h.[12] Only the presence of pain in the knee was considered; no attempt was made to detect whether the origin was articular, extra-articular, or referred, according to the methodology previously established in epidemiological studies.[2,4,12] The pain was evaluated through the VAS, ranging from 0 (no pain) to 10 (most intense pain possible) and stratified as follows: 0–3, mild; 4–6, moderate; and 7–10, strong.[12]

Knee radiographs were made with orthostatic support and included the distal femoral and proximal tibial diaphysis. The tibiofemoral angle, which consists of the intersection of the femoral and tibial anatomical axes, was measured with a goniometer. The femoral anatomical axis was obtained by drawing a line from the center of the tibial spines to the region 10 cm proximal to these at the midpoint between the lateral and medial cortices of the femur. The tibial anatomical axis was drawn from the middle of the tibial spines to a point 10 cm distal on the tibia, in the midline between the lateral and medial cortices.[13] It was considered: varus, less than 5° of tibiofemoral valgus; neutral, between 5° and 9° of valgus; and valgus, equal to or greater than 10°. The Kellgren and Lawrence[14] classification was used to assess the degree of arthrosis. Grade II was considered radiographic arthrosis.[14] This classification was used because it includes more discrete and initial alterations of arthrosis, being more sensitive in reporting earlier degenerative changes.[14,15]

The WOMAC score, initially designed for evaluation of knee and hip osteoarthrosis, it was used by Jinks et al.[12] in a population study of knee pain prevalence. This index ranges from 0 to 96 (best to worst scores) and consists of three domains: pain (0 to 20 points); stiffness (0 to 8); and function (0 to 68). The advantage of this index is that it assesses different health and well-being dimensions, but it is specific for the knee. Severe knee pain or limitation was considered when one of the sub-items had a maximum score in the assessed domain (4).[12]

Statistical analyses were performed regarding the relationship between pain (VAS) and BMI parameters, age, gender, tibiofemoral angulation, and Kellgren-Lawrence classification in the studied groups and subgroups.

The degree of radiological arthrosis by Kellgren was analyzed statistically for the parameters age, gender, and pain (VAS). The WOMAC score and its domains were assessed between the groups.

In the present study, the data analysis focused on the most symptomatic knee (main responsible for the VAS score). Such methodology aimed to avoid compromising statistical

analysis if both limbs (knees) were evaluated as separate statistical units, as previously described by Menz.[16]

Statistical analysis

The Wilks G2 test was used to assess the correlation between gender and the pain parameters and Kellgren score in the groups and subgroups. The Pearson correlation coefficient was used to assess the relationship between pain (VAS) and the parameters age, tibiofemoral angulation, and BMI. The Mann–Whitney test was used to correlate the pain in the obese (BMI < 50) and superobese (BMI > 50) subgroups, and to assess pain parameters (VAS), tibiofemoral angulation, and age in the groups. The Kolmogorov-Smirnov test was used to compare the prevalence of arthrosis according to the Kellgren classification between groups and between subgroups. Analysis of variance (ANOVA) was used to assess the WOMAC scores and the mean tibiofemoral angulation between the groups. In the analyses with positive statistical correlation, the risk coefficient (odds ratio) was calculated when indicated. In all analyses, a significance level of $p < 0.05$ was adopted.

Results

A higher incidence of pain was observed in the severely obese group (100%) when compared with the control group (30%); this difference was statistically significant (Mann–Whitney test, $p < 0.0001$; Fig. 1). The mean VAS was 6.51 in patients from the obese group, 5.85 in the superobese group, and 1.43 in the control group. No statistically significant difference was observed between the obese and superobese groups (Mann–Whitney test, $p = 0.766$).

No difference was observed in tibiofemoral angulation between the control group and the severely obese group (Mann–Whitney, $p = 0.207$; Table 2). No statistical differences were observed between the subgroups of obese individuals with BMI < 50 and BMI > 50 (Mann–Whitney, $p = 0.415$).

No difference was detected in the prevalence of arthrosis (according to the Kellgren classification) between the control group and the severely obese group (Kolmogorov-Smirnov test, $p = 0.21$), nor among the subgroups of obese individuals with BMI < 50 and BMI > 50 (Kolmogorov-Smirnov test, $p = 0.117$).

Table 2 – Main results of the statistical analysis.

	Control	Obese
Pain (VAS)	NS	$p < 0.0001$
	1.4 ± 2.2	6.2 ± 2.7
WOMAC	NS	$p = 0.001$
	$11.7\% \pm 0.5\%$	$40.7\% \pm 9.5\%$
Pain (VAS) X Gender	NS	NS
Pain (VAS) X Age	NS	$p = 0.047$
Pain (VAS) X BMI	NS	NS
Age X Kellgren	$p = 0.037$	$p = 0.001$
Gender X Kellgren	NS	NS

NS, not significant ($p > 0.05$); mean ± standard deviation.

No correlation was observed between Kellgren's radiographic classification of arthrosis and gender in both the severely obese group (Wilks G2 test, $p = 0.28$) and the control group (Wilks G2 test, $p = 0.55$).

In the group of severely obese individuals, a positive correlation was observed between the age and the presence of pain (Pearson coefficient 0.312, $p = 0.047$; Fig. 2). No statistical correlation was observed between age and pain in the control group (Pearson coefficient of 0.181, $p = 0.277$). No differences were observed between the subgroups of obese individuals with BMI < 50 and BMI > 50, with Pearson coefficients of 0.277 ($p = 0.254$) and −0.252 ($p = 0.395$), respectively.

No correlation between pain measured by VAS and gender were observed in the severely obese group (Wilks G2 test, $p = 0.594$) and in the control group (Wilks G2 test, $p = 0.541$). No higher prevalence of pain was observed in a given gender in the subgroup of obese individuals with BMI < 50 or in the subgroup with BMI > 50 (Wilks G2 tests, $p = 0.192$ and $p = 0.250$, respectively).

No correlation was observed between BMI and pain measured by VAS in the severely obese group (Pearson coefficient: 0.206; $p = 0.195$) or in the control group (Pearson coefficient:

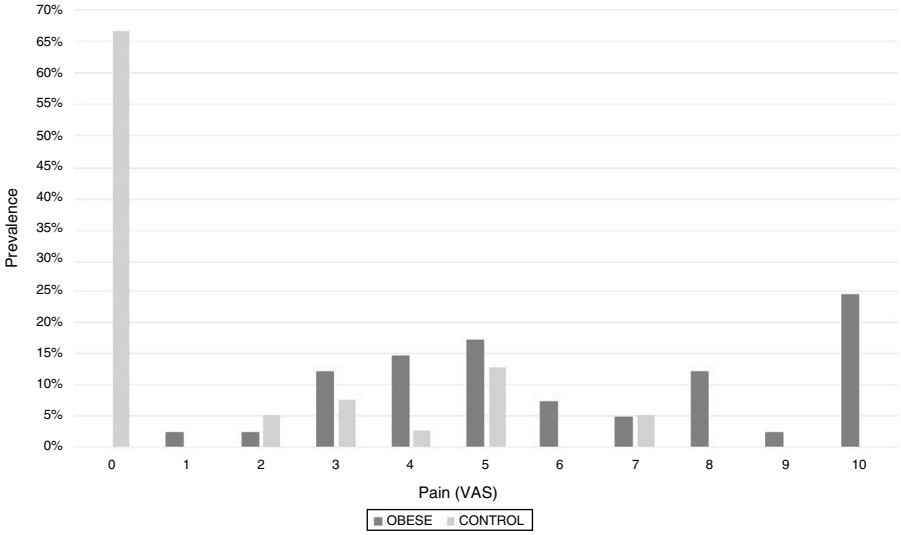

Fig. 1 – Prevalence of pain (VAS) in the severely obese and control groups.

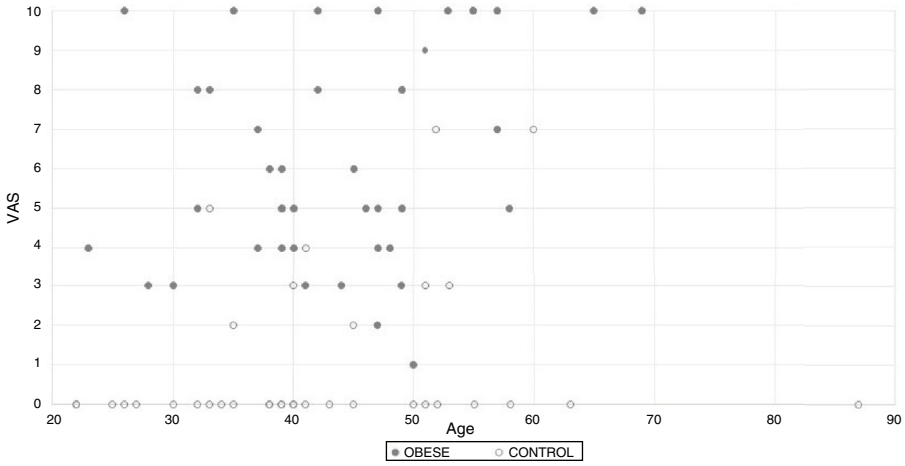

Fig. 2 – Pain (VAS) *vs.* age in the severely obese and control groups.

−0.075; $p = 0.649$). No statistical correlation was observed in the subgroups of obese individuals with BMI < 50 and BMI > 50, with Pearson correlation coefficients of 0.227 ($p = 0.25$) and −0.252 ($p = 0.395$), respectively.

No significant difference was observed between the mean tibiofemoral angulation and presence of pain by the VAS scale between the studied groups (ANOVA, $p = 0.354$). No difference was detected when correlating the subgroups of obese patients with BMI < 50 and BMI > 50 (Mann–Whitney test, $p = 0.415$).

A higher radiological arthrosis involvement with age increase was observed in both the severely obese group (Kruskal–Wallis test, $p = 0.001$) and the control group (Kruskal–Wallis test, $p = 0.037$).

The WOMAC functional scale values were worse in the severely obese group when compared with those in the control group (mean: 11.53; Mann–Whitney test, $p = 0.001$). However, no statistically significant difference was observed in this scale when comparing the subgroups of obese individuals with a BMI < 50 (mean: 49.54) and the group of obese individuals with a BMI > 50 (mean: 23.06; Mann–Whitney test, $p = 0.971$). Using the value of 18 as cutoff point[6] for functional limitation, the odds ratio of the group of severely obese patients in relation to the control group was 18.2.

On the WOMAC scale, the most seriously compromised physical function (4 points) was going up and down stairs in 35% of patients in the severely obese group, followed by heavy household work, getting in and out of a car, and standing up – with 20% severe pain/limitation.

Discussion

In the present study, it was observed that patients in the severely obese group presented higher knee pain when compared to a control group that was designated to simulate the normal-weight population. The odds ratio was calculated as 2.96. Such a finding is in agreement with Jinks et al.,[2] who have demonstrated that obese individuals are three times more likely than individuals with normal BMI to develop internal knee pain.

No relationship was observed between the degree of radiological arthrosis and the intensity of pain reported with the VAS. Although a higher incidence of knee pain was observed in the obese population when compared to the normal-weight population, this may be due to intra-articular alterations, such as degenerative meniscal lesions, as well as tendinitis that can only be visualized by magnetic resonance imaging, and not by simple radiographs.[6–9] The clinical and radiographic dissociation has already been discussed by Zhai et al.[17] and Finan et al.[18]

When assessing the subgroup of superobese (BMI > 50), no differences were observed in the levels of radiographic arthrosis and intensity of pain when compared individuals with BMI < 50. A larger sample size may be required so that differences between obese and superobese individuals can be detected.

The incidence of knee pain increased with age in the severely obese group. Other studies have also described an increased prevalence of knee pain in older age groups.[19,20]

The incidence of radiological arthrosis increased with age in both the severely obese and control groups. This fact is in agreement with the literature,[19–24] because age is a risk factor for arthrosis, as the chondrocyte function is compromised.[1]

In the present study, no difference was observed between genders regarding pain in both the study group and the control group. Some articles have described a higher incidence of knee pain in females.[19–21,25] Some authors[15,20,25] have attempted to explain the greater sensation of pain in women through social and educational issues. However, a population study conducted in Salvador, Brazil showed a higher incidence of knee pain in men.[26]

O'Connor[25] and Srikanth et al.[27] demonstrated that the female gender would be a predisposing factor for arthrosis. However, in the present study, no difference in radiographic arthrosis involvement was observed between genders.

No correlation was found in the present study between BMI and pain intensity, both when correlating the severely obese group with the control and when correlating the subgroups of obese individuals with BMI < 50 or >50. This result could be justified by the action of systemic factors (adipokines and metabolic syndrome) that would lead to musculoskeletal

system involvement and pain, which would not be determined by mechanical factors alone.[4,5] If only weight and BMI were related to pain in obese individuals, the intensity of pain would increase linearly with these parameters,[4] which was not detected in the present study.

Sharma et al.[28] demonstrated that poor knee alignment, excessive varus or valgus, and obesity would be related to a higher propensity for progression of arthrosis. High BMI accelerates the process of cartilage wear in the medial compartment in cases of genu varum. Poor knee alignment and BMI would jointly influence arthrosis progression. In the present study, no significant differences were observed in the tibiofemoral axis between the severely obese group and the control group. This fact may be explained in part by the relatively young age the present sample (mean age: 44 years), who would not yet have presented deformity of the coronal alignment of the knee due to the degenerative process.[7]

The functional performance, measured by the WOMAC score, presented a worse outcome in the groups with high BMI, as previously described by other authors.[10,11,15]

The WOMAC score in the physical function domain showed a serious impairment in the performance of going up and down stairs in 35% of the subjects in the severely obese group. This value is higher than the 23% observed by Jinks et al. doing the same task.[24] in a population of rural workers aged above 50 years. Another significant result was the 20% rate of intense pain on standing up and getting in and out of a car, also described in other studies.[11,29] These data are of significant interest and have objective and planning repercussions: the care sector for obese patients should be located preferably on the ground floor, not requiring the use of stairs. In addition, reinforced seats should be available in a quantity compatible with the demand.

A limitation of the present study is the fact that it evaluated a small number of patients; therefore, it was not possible to show differences between subgroups of obese patients with BMI < 50 and BMI > 50. A strength of the present study is that it represents an original work in Brazil, addressing the significant knee pain observed in severely obese patients. This is a special class of patients with specific clinical and psychosocial data.[1,20,30]

The analysis of the peculiarities of the clinical and epidemiological factors of the obese patients can be useful in resource allocation and in the formulation of guidelines of programs for severe obesity treatment. These data are useful, especially in the public health system, in order to take advantage of the limited resources to meet the demands of these patients. Not only bariatric surgery but also other specialties, such as plastic and orthopedic surgeries, especially of the knee, need to be considered in the broader treatment of these individuals.

Conclusion

A higher incidence of knee pain was observed in the severely obese patients when compared with control groups.

A positive correlation was observed between age progression and arthrosis in the severely obese and control groups.

In the severely obese group, pain increased with the progression of age.

The WOMAC index was worse in the severely obese group.

Conflicts of interest

The authors declare no conflicts of interest.

REFERENCES

1. Harms S, Larson R, Sahmoun AE, Beal JR. Obesity increases the likelihood of joint replacement surgery among younger adults. Int Orthop. 2007;31(1):23–6.
2. Jinks C, Jordan K, Croft P. Disabling knee pain—another consequence of obesity: results from a prospective cohort study. BMC Public Health. 2006;6:258.
3. Coggon D, Reading I, Croft P, McLaren M, Barrett D, Cooper C. Knee osteoarthritis and obesity. Int J Obes Relat Metab Disord. 2001;25(5):622–7.
4. Sowers M, Karvonen-Gutierrez CA, Palmieri-Smith R, Jacobson JA, Jiang Y, Ashton-Miller JA. Knee osteoarthritis in obese women with cardiometabolic clustering. Arthritis Rheum. 2009;61(10):1328–36.
5. Li H, George DM, Jaarsma RL, Mao X. Metabolic syndrome and components exacerbate osteoarthritis symptoms of pain, depression and reduced knee function. Ann Transl Med. 2016;4(7):133.
6. Guermazi A, Niu J, Hayashi D, Roemer FW, Englund M, Neogi T, et al. Prevalence of abnormalities in knees detected by MRI in adults without knee osteoarthritis: population based observational study (Framingham Osteoarthritis Study). BMJ. 2012;345:e5339.
7. von Eisenhart-Rothe R, VGraichen H, Huldelmaier M, Vogl T, Sharma L, Eckstein F. Femorotibial and patelar cartilage loss in patients prior to total knee arthroplasty, heterogeneity, and correlation with alignment of the knee. Ann Rheum Dis. 2006;65(1):69–73.
8. Laberge MA, Baum T, Virayavanich W, Nardo L, Nevitt MC, Lynch J, et al. Obesity increases the prevalence and severity of focal knee abnormalities diagnosed using 3 T MRI in middle-aged subjects—data from the Osteoarthritis Initiative. Skeletal Radiol. 2012;41(6):633–41.
9. Fairley J, Toppi J, Cicuttini FM, Wluka AE, Giles GG, Cook J, et al. Association between obesity and magnetic resonance imaging defined patellar tendinopathy in community-based adults: a cross-sectional study. BMC Musculoskelet Disord. 2014;15:266.
10. Frilander H, Viikari-Juntura E, Heliövaara M, Mutanen P, Mattila VM, Solovieva S. Obesity in early adulthood predicts knee pain and walking difficulties among men: a life course study. Eur J Pain. 2016;20(8):1278–87.
11. Tamura LS, Cazzo E, Chaim EA, Piedade SR. Influence of morbid obesity on physical capacity, knee-related symptoms and overall quality of life. A cross-sectional study. Rev Assoc Med Bras. 2017;63(2):142–7.
12. Jinks C, Jordan K, Croft P. Measuring the population impact of knee pain and disability with the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). Pain. 2002;100(1–2):55–64.
13. Hinman RS, May RL, Crossley KM. Is there an alternative to the full-leg radiograph for determining knee joint alignment in osteoarthritis? Arthritis Rheum. 2006;55(2):306–13.
14. Kellgren JH, Lawrence JS. Radiological assessment of osteo-arthrosis. Ann Rheum Dis. 1957;16(4):494–502.

15. Cho JH, Chang BC, Yoo HJ. Gender Differences in the correlation between symptom and radiographic severity in patient with knee osteoarthritis. Clin Orthop Relat Res. 2010;468(7):1749–58.
16. Menz H. Two feet, or one person? Problems associated with statistical analysis of paired data on foot and ankjle medicine. Foot. 2004;14(1):2–5.
17. Zhai G, Blizzard L, Srikanth V, Ding C, Cooley H, Cicuttini F, et al. Correlates of knee pain in older adults: Tasmanian Older Adult Cohort Study. Arthritis Rheum. 2006;55(2): 264–71.
18. Finan PH, Buenaver LF, Bounds SC, Hussain S, Park RJ, Haque UJ, et al. Discordance between pain and radiographic severity in knee osteoarthritis: findings from quantitative sensory testing of central sensitization. Arthritis Rheum. 2013;65(2):363–72.
19. Zhang J, Song L, Liu G, Zhang A, Dong H, Liu Z, et al. Risk factors for and prevalence of knee osteoarthritis in the rural areas of Shanxi Province North China: a COPCORD study. Rheumatol Int. 2013;33(11):2783–8.
20. Zang CH, Zeng QY, Li XF, Dong HY, Zhang AL, Zhao Q. A cross-sectional population survey of knee osteoarthritis in Taiyuan region. Zhonghua Nei Ke Za Zhi. 2006;45(7): 533–6.
21. Ritter MA, Wing JT, Berend ME, Davis KE, Meding JB. The clinical effect of gender on outcome of total knee arthroplasty. J Arthroplasty. 2008;23(3):331–6.
22. Deere KC, Clinch J, Holliday K, McBeth J, Crawley EM, Sayers A, et al. Obesity is a risk factor for musculoskeletal pain in adolescents: findings from a population-based cohort. Pain. 2012;153(9):1932–8.
23. Jhun HJ, Sung NJ, Kim SY. Knee pain and its severity in elderly Koreans: prevalence, risk factors and impact on quality of life. J Korean Med Sci. 2013;28(12):1807–13.
24. Jinks C, Jordan KP, Blagojevic M, Croft P. Predictors of onset and progression of knee pain in adults living in the community. A prospective study. Rheumatology (Oxford). 2008;47(3):368–74.
25. O'Connor MI. Osteoarthritis of the hip and knee: sex and gender differences. Orthop Clin North Am. 2006;37(4):559–68.
26. Sá KN, Pereira CM, Souza RC, Baptista AF, Lessa I. Knee pain prevalence and associated factors in a Brazilian population study. Pain Med. 2011;12(3):394–402.
27. Srikanth VK, Fryer JL, Zhai G, Winzenberg TM, Hosmer D, Jones G. A meta-analysis of sex differences prevalence, incidence and severity of osteoarthritis. Osteoarthritis Cartilage. 2005;13(9):769–81.
28. Sharma L, Cahue S, Dunlopp DD. The effect of body weight on progression of knee osteoarthritis: the mediating role of malalignment. Arthritis Rheum. 2000;43(3):568–75.
29. Gomes-Neto M, Araujo AD, Junqueira ID, Oliveira D, Brasileiro A, Arcanjo FL. Comparative study of functional capacity and quality of life among obese and non-obese elderly people with knee osteoarthritis. Rev Bras Reumatol Engl Ed. 2016;56(2):126–30.
30. Louie GH, Ward MM. Socioeconomic and ethnic differences in disease burden and disparities in physical function in older adults. Am J Public Health. 2011;101(7):1322–9.