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Obesity and the risk of multiple or severe frequent knee pain episodes: a 4-year follow-up of the ELSA-Brasil MSK cohort

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BACKGROUND/OBJECTIVE: Knee pain is an important health problem due to its high prevalence, negative impact on daily activities and quality of life, and societal burden. While the link between excess weight and knee pain has been well-documented in the literature, many studies are limited to patients with osteoarthritis or use cross-sectional data. This longitudinal study investigated whether overweight and obesity were associated with the frequency and severity of frequent knee pain (FKP) episodes over 4 years in civil servants enrolled in the ELSA-Brasil MSK cohort.
METHODS: Knee pain was assessed during baseline face-to-face interviews (2012–2014) and four yearly telephone follow-ups (2015–2019). Disabling FKP episodes or those of moderate to very severe intensity were classified as severe. Multinomial logistic regression models adjusted for confounders were used to test for associations in two participant groups: those with knee pain at baseline (prognosis cohort) and those without knee pain (incidence cohort).
RESULTS: A total of 2644 participants were included: 54.2% female, mean age 55.8 (SD 8.8) years. In the incidence cohort ($n = 1896$), obesity increased the risk of one (OR: 1.63; 95% CI 1.13–2.37) and multiple FKP episodes (OR: 2.61; 95% CI 1.71–3.97), as well as the risk of non-severe (OR: 1.72; 95% CI 1.04–2.84) and severe FKP episodes (OR: 2.10; 95% CI 1.50–2.95). In the prognosis cohort ($n = 748$), obesity increased the risk of multiple (OR: 2.54; 95% CI 1.60–4.05) and severe FKP episodes (OR: 2.31; 95% CI 1.49–3.59). Overweight presented the same trends but fell short of significance.
CONCLUSIONS: These results provide further support that overweight and obesity are important contributors to the incidence and worsening of FKP, and that weight management must be prioritized in multidisciplinary knee pain prevention and treatment programs to reduce the burden of musculoskeletal disorders.

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INTRODUCTION

Painful musculoskeletal (MSK) disorders are currently ranked among the top 20 causes of disability-adjusted life-years across all age groups globally [1]. They have also been the most common causes of years lived with disability worldwide for the last 20 years [2]. Knee pain is a common MSK problem that increases with age and body mass index [3], and it could lead to physical disability and decreased quality of life [4]. Frequent knee pain (FKP) is often defined as pain that occurs on most days of at least one month [5] and, although it is a common symptom of knee osteoarthritis (OA), it may be present regardless of an OA diagnosis [6].

Obesity is a recognized risk factor for a variety of noncommunicable diseases and is a serious morbidity in itself, which may contribute to reductions of 5 to 20 years in life expectancy [7]. Multiple studies conducted in high-income countries have previously demonstrated an association between overweight/obesity and MSK pain [8]. Among knee pain studies, obesity was found to increase the 3-year risk of severe knee symptoms according to WOMAC pain and physical function subscales [9], and weight gain was associated with worsening knee symptoms (pain, stiffness and function) after 2 years, especially in individuals with obesity [10]. Moreover, weight loss interventions seem to be effective in reducing knee pain among adults with overweight/obesity [11].

Brazil is a middle-income country facing a rapid demographic transition along with a surge in overweight/obesity prevalence [12]. According to the 2019 Brazilian National Health Survey, 1 in 4 adults have obesity [13]. A recent cross-sectional analysis from the largest cohort investigating MSK disorders in Brazilian adults showed a dose-response association between levels of obesity and chronic MSK pain, particularly for pain located at weight-bearing joints [14]. A meta-analysis on risk factors for knee OA, a common cause of FKP, has estimated that overweight or obesity accounts for 25% of new-onset knee pain, while only 5% might be attributed to a previous knee injury [15].

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Despite the high prevalence of knee pain and associated disability, most studies on the relation between excess weight and these outcomes are cross-sectional or restricted to patients with knee OA. Longitudinal investigations in non-clinical participants are important to assess whether excess weight enhances the risk and severity of knee pain in this population. Evidence on the role of overweight/obesity in the risk of FKP episodes can inform healthcare management and policy-making and contribute to reducing the burden of MSK disorders, especially in fast-ageing countries.

METHODS

This study investigated whether overweight and obesity were associated with the frequency and severity of FKP episodes over 4 years in a large sample of Brazilian civil servants: (1) individuals without FKP and CKP (incidence cohort); and (2) individuals with FKP and/or CKP (prognosis cohort) at baseline.

Study design and participants

A longitudinal, prospective observational study with a 4-year follow-up was conducted using data from the Brazilian Longitudinal Study of Adult Health - Musculoskeletal cohort (ELSA-Brasil MSK). ELSA-Brasil MSK is an ancillary study of ELSA-Brasil [16], comprising of 2901 active or retired civil servants from the Universidade Federal de Minas Gerais (UFMG) and Centro Federal de Educação Tecnológica de Minas Gerais at cohort inception. A detailed description of the ELSA-Brasil MSK cohort has been published elsewhere [17]. Individuals who completed baseline assessments for the evaluation of knee pain and overweight/obesity, as well as at least 4 yearly telephone follow-ups, were eligible for inclusion in this study ($n = 2644$) (Fig. 1).

Ethical approval

ELSA-Brasil MSK was approved by the ethics and research committee of the UFMG, Belo Horizonte, MG, Brazil [protocol COEP/UFMG, Etic 186/06; CEP 1.160.939; CAAE 0186.1.203.000-06]. The study was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments, and all participants signed a written informed consent after they had been informed of the details of the study.

Assessment and definition of knee pain

At baseline of ELSA-Brasil MSK (2012–2014), participants underwent a face-to-face interview where knee pain was investigated by the following questions: *"In the last 12 months, have you experienced pain, discomfort or stiffness in the [left/right] knee?"*; If yes, *"Did you have pain, discomfort or stiffness on most days of at least 1 month in the [left/right] knee?"* and *"Did this problem in the [left/right] knee last more than 6 months?"* A body diagram was used to assist with pain location. Those with positive answers (for at least one knee) to the first and second, and/or first and third

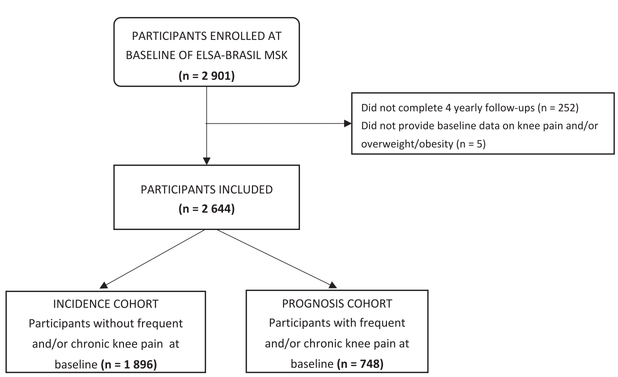

Fig. 1 Flowchart of participants included in the analysis. ELSA-Brasil MSK: Brazilian Longitudinal Study of Adult Health Musculoskeletal cohort. Frequent knee pain = knee pain, discomfort or stiffness on most days of at least 1 month in the last 12 months. Chronic knee pain = knee pain, discomfort or stiffness last more than 6 months in the last 12 months.

questions, were considered to have, respectively, frequent (FKP) and/or chronic knee pain (CKP) at baseline, and defined as the prognosis cohort. Those with negative answers both to FKP and CKP questions were defined as the incidence cohort (Fig. 1). The choice to include individuals with CKP and/or FKP on the definition of the prognosis is justified because both knee pain phenotypes are clinically relevant and frequently overlap at baseline: 58.8% of participants with knee pain >6 months (CKP) also reported pain on most days of at least one month (FKP) (Supplementary Figure). Furthermore, by excluding CKP and/or FKP from the at-risk population, the incident cohort included only individuals free of relevant knee pain in the last 12 months.

Between 2015 and 2019, 4 yearly telephone follow-ups were conducted to enquire about the presence of FKP in each knee, defined as pain on most days of the previous 30 days, as well as its intensity (using a 5-point Likert scale ranging from very mild to very severe) and associated disability. Disability was defined as FKP that prevented normal daily activities (e.g., work, domestic or leisure activities) in the previous 30 days.

The total number of FKP episodes during follow-up ranged from 0 (absent at all follow-ups) to 4 (present at all follow-ups). Participants who reported at least one episode of moderate, severe, or very severe FKP and/or at least one episode of disabling FKP pain were considered severe cases.

Assessment of overweight/obesity

Baseline anthropometric evaluations were performed by trained and certified examiners using standardized and calibrated instruments, according to a pre-defined protocol [18]. Weight (kg) and height (cm) were measured with the participant barefoot, wearing light clothes and standing straight with the head level, using Toledo® scales (model 2096PP, Toledo, BR, capacity of 200 kg and accuracy of 50 g) and a SECA® stadiometer (model SE-216, Hamburg, BRD, accuracy of 0.1 cm), respectively.

Body mass index (BMI) was calculated as weight (kg)/height $(m)^2$ and categorized as (1) normal weight: ≤24.9 kg/m^2, (2) overweight: 25–29.9 kg/m^2 and (3) obesity: ≥30 kg/m^2 [19].

Potential confounders

Baseline data on sociodemographic and lifestyle/clinical characteristics were collected through structured interviews and validated questionnaires [17]. Sex, age, educational level (university degree, secondary school, elementary school or lower), leisure-time physical activity (LTPA) and depression were considered confounders given consistent evidence on their relationship with both obesity and pain [20–22]. Self-reported skin colour/race (white, brown, black) and nature of occupation at baseline (or last occupation if retired) were also considered potential confounders because they have previously been shown to be associated with either obesity or pain [20, 21, 23].

The nature of occupation was categorized into two groups based on the description of the work task performed by the participant: non-manual (reference) and manual [24]. LTPA was assessed by the long version of the International Physical Activity Questionnaire and categorized as follows: insufficient (no LTPA practice or some LTPA, but not meeting the other two categories); moderate (≥3 days of vigorous-intensity LTPA for at least 20 min/day; or ≥5 days of moderate-intensity LTPA and/or walking, in combination or alone, at least 30 min/day; or ≥5 days of any combination of walking, moderate-or-vigorous-intensity LTPA achieving a minimum of 600 MET-min/week); or vigorous (vigorous-intensity LTPA on at least 3 days, accumulating a minimum of 1500 MET-min/week; or ≥7 days of any combination of walking, moderate-or-vigorous-intensity LTPA accumulating a minimum of 3000 MET-min/week) [25]. Depression was assessed through the adapted Brazilian Portuguese version of the Clinical Interview Schedule-Revised (CIS-R), considering the sum of all depressive symptoms [26].

Statistical analysis

Characteristics of the sample were described as frequencies and percentages, or as means and standard deviations (SD). Associations of overweight/obesity with the number and severity of FKP episodes were tested in multinomial logistic regressions considering the two distinct cohorts separately: prognosis and incidence cohorts. Three-category outcomes were computed for the number of FKP episodes (absent=reference, 1, and 2 to 4), and their severity (absent=reference, non-severe, and severe).

After the bivariate analysis (the crude model), the models were adjusted by sex, age, self-reported skin colour/race, education, nature of the occupation, leisure-time physical activity and depression. All adjustments were retained in the adjusted model regardless of the *p* value. Crude and adjusted Odds Ratios (OR) with their respective 95% confidence intervals (95% CI) were described. Statistical significance was set at $p < 0.05$, and the goodness-of-fit of the final adjusted models was assessed using a generalized Hosmer–Lemeshow goodness-of-fit test for multinomial logistic regression models (*mlogitgof* command in Stata), with $p \geq 0.05$ meaning the models were correctly fitted. All analyses were performed using Stata statistical software (version 14.0; StataCorp, College Station, Texas).

RESULTS

Of the 2644 participants included, the baseline mean age was 55.8 (SD 8.82) years and 54.2% were female. The majority of participants had a university education (67.5%). Table 1 shows the characteristics of the total sample, as well as those of the incidence and prognosis cohorts, which included 1896 and 748 participants, respectively.

The average interval between baseline assessments and the first telephone follow-up was 2.0 (SD 0.58) year. The interval between each subsequent follow-up was 1.0 (SD 0.17) year for the first to the second follow-up, 1.1 (SD 0.22) years for the second to third follow-up and 1.0 (SD 0.23) year for the third to the fourth follow-up.

Figure 2 presents the distribution of the number and severity of FKP episodes during the 4-year follow-up period. In the incidence cohort, FKP was reported by 24.4% of participants, with most of them having only one episode during the follow-up period. In the prognosis cohort, 64.3% of participants reported at least one episode of FKP during follow-up, with the majority of them reporting multiple episodes. The proportion of severe FKP was higher in the prognosis cohort compared to the incidence cohort, regardless of the number of episodes (Fig. 2).

Crude and adjusted OR and 95% CI for associations between overweight/obesity and number of FKP episodes after 4 years of follow-up are described in Table 2. In adjusted analyses, the group with obesity were 1.63 times more likely to have one FKP episode compared to the normal weight group in the incidence cohort (95% CI 1.13–2.34). The risk of multiple FKP episodes was higher in both cohorts for participants with obesity being 2.39 (95% CI 1.59–3.60) times more likely in the incidence cohort and 2.38 (95% CI 1.51–3.77) times more likely in the prognosis cohort (Table 2). Being overweight also appears to increase the risk of single and multiple episodes of FKP, although statistical significance was borderline.

Similar results were observed for the association between overweight/obesity and FKP severity (Table 3). In adjusted analyses, the risk of non-severe FKP episodes was increased in the presence of obesity only in the incidence cohort (OR: 1.71; 95% CI 1.05–2.81). Obesity increased 1.99 (95% CI 1.43–2.78) and 2.17 (95% CI 1.41–3.36) the risk of severe FKP in the incidence and prognosis cohorts, respectively, compared to normal weight. Overweight showed similar trends, but the associations did not reach statistical significance.

DISCUSSION

The results of this study showed that obesity increased the 4-year risk of multiple and severe episodes of FKP in Brazilian civil servants with or without previous frequent and/or chronic knee pain at baseline. Additionally, obesity was also associated with a higher risk of a single FKP episode over 4 years, and of non-severe knee pain episodes only among those without previous knee pain, i.e. incidence cohort. The overweight group showed similar trends but fell short of statistical significance.

Table 1. Study population characteristics at baseline, ELSA-Brasil MSK (2012–2014).

Characteristics	Incidence cohort[a] ($n = 1896$)	Prognosis cohort[b] ($n = 748$)	All ($n = 2644$)
Men	960 (50.6)	252 (33.7)	1212 (45.8)
Women	936 (49.4)	496 (66.3)	1432 (54.2)
Age group			
<45	214 (11.3)	56 (7.5)	270 (10.2)
45–54	716 (37.8)	248 (33.2)	964 (36.5)
55–64	666 (35.1)	288 (38.5)	954 (36.1)
65+	300 (15.8)	156 (20.8)	456 (17.2)
Self-reported skin colour/race*			
White	957 (51.2)	339 (45.6)	1296 (49.6)
Brown	639 (34.2)	271 (36.6)	910 (34.9)
Black	219 (11.7)	113 (15.2)	332 (12.7)
Asian	41 (2.2)	17 (2.3)	58 (2.2)
Indigenous	14 (0.7)	1 (0.1)	15 (0.6)
Educational level			
University education	1 309 (69.0)	477 (63.8)	1786 (67.6)
Secondary school	458 (24.2)	207 (27.7)	665 (25.1)
Primary school or lower	129 (6.8)	64 (8.5)	193 (7.3)
Nature of occupation**			
Non-manual	1 658 (88.0)	661 (89.2)	2319 (88.4)
Manual	225 (12.0)	80 (10.8)	305 (11.6)
LTPA			
Insufficient	1 321 (69.7)	544 (72.7)	1865 (70.5)
Moderate	409 (21.6)	145 (19.4)	554 (21.0)
Vigorous	166 (8.7)	59 (7.9)	225 (8.5)
Depression			
No	1 812 (95.6)	685 (91.6)	2497 (94.4)
Yes	84 (4.4)	63 (8.4)	147 (5.6)
BMI			
Normal weight (<25 kg/m^2)	761 (40.1)	217 (29.0)	978 (37.0)
Overweight (25–29.9 kg/m^2)	777 (41.0)	300 (40.1)	1077 (40.7)
Obesity (≥30 kg/m^2)	358 (18.9)	231 (30.9)	589 (22.3)

Data presented as frequencies (percentages) for valid cases only.
LTPA leisure-time physical activity, *BMI* body mass index.
[a]Cohort without frequent and/or chronic knee pain at baseline.
[b]Cohort with frequent and/or chronic knee pain at baseline.
Frequency of missing values: *33, **20.

Previous longitudinal studies also found positive associations between obesity and the risk of developing painful MSK conditions. Haukka et al. [27] assessed the combined effect of obesity, physical workload, LTPA and smoking on predicting multisite pain after 2 years in kitchen workers and found that individuals with obesity had 30% greater chances of experiencing pain compared to normal-weight peers. In the HUNT study, a large cohort investigating MSK disorders in the Norwegian population, obesity increased the chances of developing chronic widespread pain by 35% [28]. Additionally, Jinks et al. [9] also found that, in older adults, obesity increased the risk of developing severe knee pain by 2.79 times after three years of follow-up.

Our study showed some differences between the incidence and prognosis cohorts concerning the role of obesity in increasing the risk of FKP. While obesity was found to increase the risk of single, multiple, non-severe and severe FKP episodes in individuals without previous knee pain, it was only associated with worse outcomes (multiple and severe FKP episodes) in those reporting knee pain at baseline. This might indicate that obesity contributes to worsening baseline knee pain, more than simply predicting its recurrence. For instance, Bindawas [29] had previously demonstrated that the combination of obesity and FKP at baseline predicted pace reduction among older adults after six years of follow-up and that the effect of FKP combined with obesity was greater than the isolated effects of either of these factors [29]. On the other hand, differences in the results of both cohorts investigated in our study could also be a result of an index event bias (or collider stratification bias), a type of selection bias that can affect research on the risk of disease sequelae when multiple risk factors for sequelae are also risk factors for having the disease in the first place, as in the case of obesity for knee pain [30].

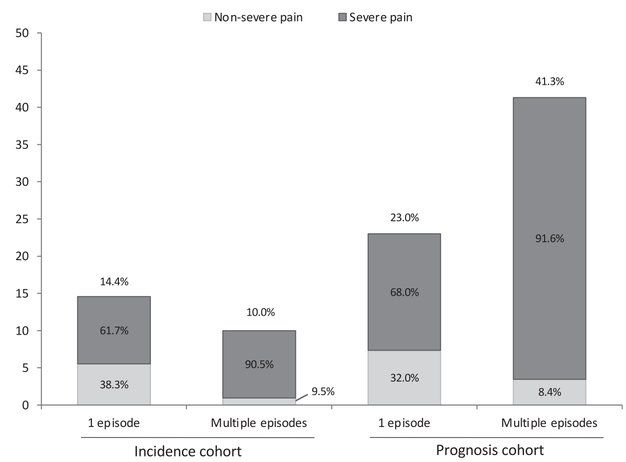

Fig. 2 Distribution of the number and severity of frequent knee pain episodes, ELSA-Brasil MSK (2015–2019). $N = 2644$. The incidence cohorts included participants without frequent (FKP) and/or chronic knee pain (CKP) at baseline, while the prognosis cohort included individuals with FKP and/or CKP. Numbers outside the bars represent cumulative incidence (incidence cohort) and frequency (prognosis cohort) of FKP according to the number of episodes. Numbers inside the bars represent pain severity frequencies within each number of episodes category.

The higher frequency of severe FKP episodes in the prognosis cohort compared to the incidence cohort is consistent with the recognized role of a previous pain experience as one of the most important risk factors for a new and worst pain episode [20, 21]. However, it is also worth noting that other factors, such as higher mean age and proportion of female participants in the prognosis cohort, may have also contributed to the differences observed between the two investigated cohorts.

The probable mechanisms underlying the effects of overweight/obesity on the risk of a future episode of knee pain are mechanical overload and obesity-induced systemic inflammation [31]. Mechanical overload, particularly in large weight-bearing joints like knees and hips, is known to alter chondrocyte metabolism and accelerate cartilage degeneration [31, 32]. Systemic inflammation related to obesity can also promote joint and tissue damage [31–33], but it can also act as a trigger for neural mechanisms of pain amplification within the central nervous system, i.e. central sensitization [34]. Evidence from studies investigating weight loss interventions provides further support for the causal role of obesity in painful joint conditions [10, 35, 36]. In addition to pain improvement with the reduction of body weight, some of these previous studies also showed a reduction in pressure pain thresholds, which indicates an improvement in central sensitization [35].

Some of the strengths of this study are the large number of included participants, the use of multiple pain assessments over a long-term follow-up, and the adjustment of all analyses for important confounders (e.g., physical activity and depression) that are generally not assessed in large studies using validated questionnaires such as those used in ELSA-Brasil MSK. Another advantage is the reporting of associations in both an incidence and prognosis cohort, given that participant recruitment that is not conditioned to pre-existing symptoms is uncommon in cohorts of MSK disorders. Possible limitations included the longer interval between baseline and the first available follow-up (about twice as long as the intervals between each subsequent follow-up), as well as possible pain fluctuations not captured by yearly pain assessments (which might underestimate the incidence of FKP, although there is no reason to suppose that pain fluctuation was affected by overweight/obesity status). As a consequence, the magnitudes of the associations found between knee pain and overweight/obesity might be conservative, as non-differential misclassification of outcome will generally bias associations toward the null. Finally, although the ELSA-Brasil MSK has considerable sociodemographic and economic variability, its sample was not intended to represent the Brazilian population

Table 2. Association of overweight/obesity with the number of frequent knee pain episodes, ELSA-Brasil MSK (2015–2019).

	Unadjusted model OR (95% CI)		**Adjusted[a] model OR (95% CI)**	
	1 episode	**Multiple episodes**	**1 episode**	**Multiple episodes**
Incidence cohort[b] ($n = 1857$)				
Normal weight (BMI < 25 kg/m^2)	1.00	1.00	1.00	1.00
Overweight (BMI 25-29.9 kg/m^2)	1.18 (0.88–1.58)	1.16 (0.81–1.67)	1.24 (0.92–1.68)	1.17 (0.80–1.70)
Obesity (BMI ≥ 30 kg/m^2)	1.61 (1.13–2.28)*	2.46 (1.67–3.62)**	1.63 (1.13–2.34)*	2.39 (1.59–3.60)**
Prognosis cohort[c] ($n = 734$)				
Normal weight (BMI < 25 kg/m^2)	1.00	1.00	1.00	1.00
Overweight (BMI 25–29.9 kg/m^2)	1.19 (0.76–1.86)	1.23 (0.82–1.84)	1.16 (0.73–1.85)	1.23 (0.80–1.89)
Obesity (BMI ≥ 30 kg/m^2)	1.20 (0.72–2.01)	2.36 (1.54–3.63)**	1.11 (0.65–1.88)	2.38 (1.51–3.77)**

OR odds ratio, *CI* confidence interval, *BMI* body mass index, Multinomial Regression.
[a]Adjusted by sex, age, self-reported skin colour/race, education, nature of the occupation, leisure-time physical activity and depression.
[b]Cohort without frequent and/or chronic knee pain at baseline.
[c]Cohort with frequent and/or chronic knee pain at baseline.
*$p < 0.05$; **$p \leq 0.001$.

Table 3. Association of overweight/obesity with frequent knee pain severity, ELSA-Brasil MSK (2015–2019).

	Unadjusted model OR (95% CI)		Adjusted[a] model OR (95% CI)	
	Non-Severe knee pain	Severe knee pain	Non-Severe knee pain	Severe knee pain
Incidence cohort[b] ($n = 1857$)				
Normal weight (BMI < 25 kg/m^2)	1.00	1.00	1.00	1.00
Overweight (BMI 25–29.9 kg/m^2)	1.04 (0.68–1.58)	1.23 (0.94–1.62)	1.06 (0.69–1.63)	1.28 (0.96–1.70)
Obesity (BMI ≥ 30 kg/m^2)	1.66 (1.02–2.69)*	2.04 (1.49–2.80)**	1.71 (1.05–2.81)*	1.99 (1.43–2.78)**
Prognosis cohort[c] ($n = 734$)				
Normal weight (BMI < 25 kg/m^2)	1.00	1.00	1.00	1.00
Overweight (BMI 25–29.9 kg/m^2)	1.01 (0.57–1.77)	1.27 (0.87–1.85)	0.99 (0.55–1.77)	1.28 (0.86–1.92)
Obesity (BMI ≥ 30 kg/m^2)	0.78 (0.39–1.56)	2.21 (1.47–3.33)**	0.76 (0.38–1.54)	2.17 (1.41–3.36)**

OR odds ratio, *CI* confidence interval, *BMI* body mass index, Multinomial Regression.
[a]Adjusted by sex, age, self-reported skin colour/race, education, nature of the occupation, leisure-time physical activity and depression.
[b]Cohort without frequent and/or chronic knee pain at baseline.
[c]Cohort with frequent and/or chronic knee pain at baseline.
*$p < 0.05$; **$p \leq 0.001$.

as it excludes the extremes of the socioeconomic population, i.e., the very rich and the very poor and unemployed. As a consequence, the observed prevalence of obesity and FKP cannot be extrapolated to the general population. However, there is no reason to suppose that the associations between obesity and FKP would apply only to the present cohort sample. As extensively debated in recent years, although sampling representativeness is necessary when we aim to estimate the prevalence of a condition in a given population (which was not the objective of this study), sampling representativeness is not required to draw valid scientific inferences for associations found in well-conducted epidemiological studies [37, 38].

This longitudinal study adds to data from high-income countries and previous cross-sectional data from ELSA-Brasil and ELSA-Brasil MSK cohorts [14, 39] on the relationship between higher levels of excess weight and MSK pain. The continuation of data collection in the later will allow future analyses addressing changes in overweight/obesity and knee pain trajectories in ageing Brazilians, contributing to much-needed evidence into modifiable risk factors for pain and disability in this population.

DATA AVAILABILITY

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

REFERENCES

1. GBD 2019 Diseases and Injuries Collaborators. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet. 2020;396:1204–22. https://doi.org/10.1016/S0140-6736(20)30925-9.
2. GBD 2019 Diseases and Injuries Collaborators. Musculoskeletal disorders-Level 2 cause. https://www.healthdata.org/results/gbd_summaries/2019/musculoskeletal-disorders-level-2-cause. Accessed 13 Feb 2023.
3. Fernandes GS, Bhattacharya A, McWilliams DF, Ingham SL, Doherty M, Zhang W. Risk prediction model for knee pain in the Nottingham community: a Bayesian modelling approach. Arthritis Res Ther. 2017;19:59. https://doi.org/10.1186/s13075-017-1272-6.
4. Ayis S, Dieppe P. The natural history of disability and its determinants in adults with lower limb musculoskeletal pain. J Rheumatol. 2009;36:583–91. https://doi.org/10.3899/jrheum.080455.
5. Leyland KM, Gates LS, Nevitt M, Felson D, Bierma-Zeinstra SM, Conaghan PG, et al. Harmonising measures of knee and hip osteoarthritis in population-based cohort studies: an international study. Osteoarthritis Cartilage. 2018;26:872–9. https://doi.org/10.1016/j.joca.2018.01.024.
6. Bindawas SM, Vennu V. Longitudinal effects of physical inactivity and obesity on gait speed in older adults with frequent knee pain: data from the Osteoarthritis Initiative. Int J Environ Res. Public Health. 2015;12:1849–63. https://doi.org/10.3390/ijerph120201849.
7. Blüher M. Obesity: global epidemiology and pathogenesis. Nat Rev Endocrinol. 2019;15:288–98. https://doi.org/10.1038/s41574-019-0176-8.
8. Chin SH, Huang WL, Akter S, Binks M. Obesity and pain: a systematic review. Int J Obes (Lond). 2020;44:969–79. https://doi.org/10.1038/s41366-019-0505-y.
9. 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. https://doi.org/10.1186/1471-2458-6-258.
10. Tanamas SK, Wluka AE, Davies-Tuck M, Wang Y, Strauss BJ, Proietto J, et al. Association of weight gain with incident knee pain, stiffness, and functional difficulties: a longitudinal study. Arthritis Care Res. (Hoboken). 2013;65:34–43. https://doi.org/10.1002/acr.21745.
11. Cooper L, Ryan CG, Ells LJ, Hamilton S, Atkinson G, Cooper K, et al. Weight loss interventions for adults with overweight/obesity and chronic musculoskeletal pain: a mixed methods systematic review. Obes Rev. 2018;19:989–1007. https://doi.org/10.1111/obr.12686.
12. Felisbino-Mendes MS, Cousin E, Malta DC, Machado ÍE, Ribeiro ALP, Duncan BB, et al. The burden of non-communicable diseases attributable to high BMI in Brazil, 1990–2017: findings from the Global Burden of Disease Study. Popul Health Metr. 2020;18:18. https://doi.org/10.1186/s12963-020-00219-y.
13. IBGE. Pesquisa nacional de saúde: 2019: atenção primária à saúde e informações antropométricas: Brasil. Instituto Brasileiro de Geografia e Estatística, Coordenação de Trabalho e Rendimento. Rio de Janeiro: IBGE, 2020; https://biblioteca.ibge.gov.br/visualizacao/livros/liv101758.pdf.
14. Costa ABP, Machado LAC, Telles RW, Barreto SM. Dose–response associations of clinical markers of obesity and duration of exposure to excess weight with chronic musculoskeletal pain: cross-sectional analysis at baseline of ELSA-Brasil Musculoskeletal cohort. Rheumatol Int. 2020;40:881–91. https://doi.org/10.1007/s00296-020-04557-w.
15. Silverwood V, Blagojevic-Bucknall M, Jinks C, Jordan JL, Protheroe J, Jordan KP. Current evidence on risk factors for knee osteoarthritis in older adults: a systematic review and meta-analysis. Osteoarthritis Cartilage. 2015;23:507–15. https://doi.org/10.1016/j.joca.2014.11.019.
16. Aquino EM, Barreto SM, Bensenor IM, Carvalho MS, Chor D, Duncan BB, et al. Brazilian longitudinal study of adult health (ELSA-Brasil): objectives and design. Am J Epidemiol. 2012;175:315–24. https://doi.org/10.1093/aje/kwr294.
17. Telles RW, Machado LAC, Costa-Silva L, Barreto SM. Cohort profile update: the Brazilian longitudinal study of adult health musculoskeletal (ELSA-Brasil MSK) cohort. Int J Epidemiol. 2022;51:391. https://doi.org/10.1093/ije/dyac084.
18. Schmidt MI, Griep RH, Passos VM, Luft VC, Goulart AC, Menezes GM, et al. Strategies and development of quality assurance and control in the ELSA-Brasil. Rev Saude Publica. 2013;47:105–12. https://doi.org/10.1590/s0034-8910.2013047003889.
19. World Health Organisation (WHO). Physical Status: the use and interpretation of anthropometry. WHO Technical Report Series 854, Geneva 1995.
20. Henschke N, Kamper SJ, Maher CG. The epidemiology and economic consequences of pain. Mayo Clin Proc. 2015;90:139–47. https://doi.org/10.1016/j.mayocp.2014.09.010.
21. Larsson B, Bjork J, Borsbo B, Gerdle B. A systematic review of risk factors associated with transitioning from regional musculoskeletal pain to chronic widespread pain. Eur J Pain. 2012;16:1084–93.

22. World Health Organization (WHO). Obesity: preventing and managing the global epidemic. Report. 1997.
23. Wei L, Wu B. Racial and ethnic differences in obesity and overweight as predictors of the onset of functional impairment. J Am Geriatr Soc. 2014;62:61–70. https://doi.org/10.1111/jgs.12605.
24. Autor DH, Levy F, Murnane RJ. The skill content of recent technological change: an empirical exploration. Q J Econ. 2003;118:1279–333.
25. Matsudo S, Araújo T, Matsudo V, Andrade D, Andrade E, Oliveira LC, et al. Questionário internacional de atividade física (IPAQ): estudo de validade e reprodutibilidade no Brasil. Rev Bras Ativ Fís Saúde. 2001;6:5–18.
26. Nunes MA, Alves MGM, Chor D, Schmidt MI, Duncan BB. Adaptação transcultural do CIS-R (Clinical Interview Schedule- Revised version) para o português no Estudo Longitudinal de Saúde do Adulto (ELSA). Rev HCPA. 2011;31:515–8.
27. Haukka E, Ojajarvi A, Takala EP, Viikari-Juntura E, Leino-Arjas P. Physical workload, leisure-time physical activity, obesity and smoking as predictors of multisite musculoskeletal pain. A 2-year prospective study of kitchen workers. Occup Environ Med. 2012;69:485–92. https://doi.org/10.1136/oemed-2011-100453.
28. Mundal I, Grawe RW, Bjorngaard JH, Linaker OM, Fors EA. Psychosocial factors and risk of chronic widespread pain: an 11-year follow-up study–the HUNT study. Pain. 2014;155:1555–61. https://doi.org/10.1016/j.pain.2014.04.033.
29. Bindawas SM. Relationship between frequent knee pain, obesity, and gait speed in older adults: data from the Osteoarthritis Initiative. Clin Interv Aging. 2016;11:237–44. https://doi.org/10.2147/cia.s100546.
30. Choi HK, Nguyen US, Niu J, Danaei G, Zhang Y. Selection bias in rheumatic disease research. Nat Rev Rheumatol. 2014;10:403–12. https://doi.org/10.1038/nrrheum.2014.36.
31. Bonakdar RA. Obesity-related pain: time for a new approach that targets systemic inflammation. J Fam Pract. 2013;62:S22–9.
32. Walsh TP, Arnold JB, Evans AM, Yaxley A, Damarell RA, Shanahan M. The association between body fat and musculoskeletal pain: a systematic review and meta-analysis. BMC Musculoskelet Disord. 2018;19:949. https://doi.org/10.1186/s12891-018-2137-0.
33. Marchand F, Perreti M, Macmahon SB. Role of the immune system in chronic pain. Nat Rev Neurosci. 2005;6:521–32. https://doi.org/10.1038/nrn1700.
34. Harte SE, Harris RE, Clauw DJ. The neurobiology of central sensitization. J Appl Behav Res. 2018;23:S53. https://doi.org/10.1111/jabr.12137.
35. Stefanik JJ, Felson DT, Apovian CM, Niu J, Margaret Clancy M, LaValley MP, et al. Changes in pain sensitization after bariatric surgery. Arthritis Care Res (Hoboken). 2018;70:1525–8. https://doi.org/10.1002/acr.23513.
36. Li JS, Tsai TY, Clancy MM, Li G, Lewis CL, Felson DT. Weight loss changed gait kinematics in individuals with obesity and knee pain. Gait Posture. 2019;68:461–5. https://doi.org/10.1016/j.gaitpost.2018.12.031.
37. Richiardi L, Pizzi C, Pearce N. Commentary: representativeness is usually not necessary and often should be avoided. Int J Epidemiol. 2013;42:1018e22. https://doi.org/10.1093/ije/dyt103.
38. Rothman KJ, Gallacher JEJ, Hatch E. Why representativeness should be avoided. Int J Epidemiol. 2013;42:1012e4. https://doi.org/10.1093/ije/dys223.
39. Machado LAC, Telles RW, Benseñor IM, Barreto SM. Prevalence of pain and associated factors in Brazilian civil servants: an introductory analysis using baseline data from the ELSA-Brasil cohort. Pain Rep. 2019;4:797 https://doi.org/10.1097/pr9.0000000000000797.

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AUTHOR CONTRIBUTIONS

ABPC, LACM, RWT and SMB contributed to the study conception and design; ABPC, RWT and SMB contributed to the analysis and interpretation of data; ABPC drafted the first version of the article; LACM, RWT and SMB revised critically the article content. All authors approved of the final version of the manuscript.

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COMPETING INTERESTS

The authors declare no competing interests.

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