SYSTEMATIC AND META-ANALYSIS

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Prevalence of sarcopenia after bariatric surgery: a systematic review and meta-analysis

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ABSTRACT

Introduction: Bariatric surgery, after failed weight loss and comorbidity resolution, can lead to postoperative sarcopenia, characterized by the gradual loss of muscle mass and strength, impacting functionality and quality of life. **Objective:** This systematic review aims to determine the prevalence of sarcopenia after bariatric surgery. **Methods:** The protocol was registered on PROSPERO (CRD42023447294). Comprehensive searches of electronic databases and journal references, without language restrictions, were conducted. Sarcopenia was defined as a progressive disorder involving muscle mass and function loss. The primary outcome was sarcopenia prevalence after bariatric surgery. Meta-analysis was realized using R software (version 4.1.0). **Results:** Among 1,445 reviewed studies from databases like MEDLINE, Embase, Web of Science, BVS, LILACS, and BDENF, eight met the criteria. The global sarcopenia prevalence was 32%, with an average age of 42 ± 10 years. It was higher in Roux-en-Y gastric bypass (RYGB) patients (59%). DXA was the primary data collection method (45%). After bariatric surgery, sarcopenia prevalence was 55% after more than a year, 3% within a year, and 24% at one year. **Conclusion:** The high sarcopenia prevalence highlights the need for healthcare professionals to enhance screening, intervention, and follow-up for this condition. Additional studies are needed to understand associated factors and develop interventions to prevent sarcopenia in this population.

Keywords: Sarcopenia; Bariatric surgery; Muscle, Skeletal; Epidemiology, Prevalence.

INTRODUCTION

Obesity, currently characterized as a global pandemic, has raised healthcare costs and led to a lower quality of life, impacted by numerous metabolic disorders.[1] Approximately 500 million adults worldwide suffer from excess weight.[2] Faced with many therapeutic failures for weight loss, bariatric surgery has become the ideal treatment option for the remission of comorbidities, as well as for weight loss and extended life expectancy. The International Federation for the Surgery of Obesity and Metabolic Disorders has identified a steadily growing increase in the number of bariatric surgeries since 2016. These data are present not only in high-income countries but also in low and middle-income countries.[3]

Bariatric surgery results in changes in body composition, such as the loss of fat mass, skeletal muscle, and bone mineral density, as well as some postoperative complications like sarcopenia.[4] Sarcopenia is defined by the European Working Group on Sarcopenia in Older People (EWGSOP)[5] as a syndrome characterized by the generalized and progressive loss of skeletal muscle mass and strength. This loss leads to an increased risk of physical disability, frailty, falls, metabolic and cardiovascular complications, and even death. Its worldwide prevalence is not yet well established, as found in literature [6-8], where the prevalence ranged from 10 to 50% depending on age group and gender.

Currently, sarcopenia has been identified as one of the primary complications of gastrointestinal surgeries. Due to the lack of prior screening for this syndrome in most of these surgeries, its diagnosis follows eventual health complications and occurs late.[9] Therefore, EWGSOP recommends that assessments of muscle mass, handgrip strength (HGS), and gait speed be conducted to screen for and diagnose sarcopenia. Muscle mass can be measured using techniques such as computerized tomography (CT), bioelectrical impedance analysis (BIA), dual-energy X-ray absorptiometry (DXA), and ultrasound. Handgrip strength and gait speed are evaluated using a dynamometer and specific exercises like walking time, respectively. The cut-off points provided by EWGSOP are used to assess these measurements.[9]

Once the risk of developing sarcopenia after bariatric surgery has been established, the literature reports on the health repercussions associated with this syndrome. However, the estimated prevalence of sarcopenia in these individuals is not well-documented. Moreover, it is crucial to raise awareness among health professionals and individuals undergoing bariatric surgery about the importance of prior screening and post-surgical follow-up. This preventive approach is essential to mitigate the severity of sarcopenia and its numerous complications.[4] Building upon the aforementioned findings, this systematic review aimed to assess the prevalence of sarcopenia in individuals who have undergone bariatric surgery.

METHODS

This systematic review and meta-analysis followed the recommendations of the Cochrane Library,[10] Joanna Briggs Institute Manual,[11] the Meta-analysis of Observational Studies in Epidemiology (MOOSE) reporting guidelines[12] and was developed according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).[13] The study's protocol was registered on the PROSPERO platform under code #CRD42023447294.

Search strategy

To answer the question "What is the prevalence of sarcopenia after bariatric surgery?" we searched six independent databases to perform the sensitive literature search: MEDLINE (by PubMed), Embase, Web of Science, Biblioteca Virtual em Saúde (BVS), Latin American and Caribbean Health Science Information (LILACS) and Base de Dados em Enfermagem (BDENF). Additionally, we hand-searched the reference lists of the included studies.

There was no language, date, document type, or publication status to include records. The last search was conducted in July 2023. Descriptors were identified in Medical Subject Headings (MeSH), Descritores em Ciências da Saúde (DeCS), and Embase Subject Headings (Emtree). Later, they were combined with the boolean operator AND, whereas their synonyms were combined with the boolean operator OR. The following meshes formed the herein-used search strategy, which was adapted based on descriptors in each database: "sarcopenia" and "bariatric surgery". The search strategy adopted in each database is presented in the **Supplementary Information (SI).**

Outcomes

The primary outcome was the prevalence of sarcopenia after bariatric surgery, defined as a progressive, generalized skeletal muscle disorder involving accelerated loss of muscle mass and function. However, this has been clinically observed in individuals who undergo bariatric surgery, as it not only leads to weight loss but also results in a significant reduction in muscle mass and bone mineral density, increasing the sarcopenia risk.

Eligibility criteria

We included observational studies (cross-sectional, case-control, or cohort studies) and randomized or nonrandomized phase I realized with adults and the elderly. We do not use gender, age group, or country of origin restrictions, nor do we use the sarcopenia diagnosis method and other subclassifications, such as moderate and severe sarcopenia. Experience studies, case series or case reports, trials, reviews, in vitro or experimental studies with animals, cost-effectiveness analysis, letters, comments, or editorials were excluded. Studies that have evaluated pregnant or lactating women and studies involving individuals who had pharmacological weight loss therapy were excluded. Furthermore, another exclusion involves individuals who have had another surgical procedure after bariatric surgery and re-operation (when more than one bariatric surgery has been performed). Participants/population were individuals who are obese, as defined by body mass index (BMI) ≥ 30 kg / m^2,[14] who have had bariatric surgery.

Study selection and data extraction

We uploaded the electronic search results from the defined databases to the Rayyan Qatar Computing Research Institute app for systematic reviews.[15]

Two reviewers (MGR, PIC) independently screened titles and abstracts. These reviewers independently assessed each eligible study to determine whether they met the inclusion criteria. Two independent reviewers (MGR, PIC) addressed any discrepancy. To create the extraction table we collected study characteristics (title, authors, year, location, and definition of sarcopenia), methods (study design, measured outcomes reported, covariates), participant characteristics (age, gender, study inclusion and exclusion criteria), pre-surgical BMI, associated factors (risk and protection), surgical technique (one type specific or mixed the included more than type of bariatric surgery), time after surgery, follow-up period (days), number and severity of study sample and sarcopenia, and data collection methods (DXA and BIA).

Quality assessment

The Joanna Briggs Institute (JBI) instrument was used for the methodological quality assessment of the systematic review of prevalence. Studies were classified as low risk of bias if the total score was equal to 9, moderate risk of bias if between 6 and 8, and high risk of bias if ≤ 5.[16] Two researchers independently (MGR, PIC) assessed the risk of bias in the chosen studies. Disagreements among the reviewers regarding the potential for bias in particular studies will be settled through discussion, occasionally involving a third author (NSG) of the review.

Statistical analysis

Descriptive statistics were used to first describe the extracted data. Prevalence rates were managed as a logit event estimate to normalize the data distribution. Logit event estimates were then back-transformed into proportions with 95% CI when pooled analysis was carried out. The overall prevalence rates were reported in percentages.[11]

This meta-analysis estimated sarcopenia prevalence using the crude proportions method (PRAW) with random effect. We chose this method because it corrected the overestimation of the weight of studies with esti-

mates very close to 0% or 100%.[17] Subgroup analyses were performed by type of surgery, data collection methods, average time of surgical performance, and design of studies.

Heterogeneity was assessed by the random-effects model, the chi-square test was applied with a significance of $p < 0.10$, and its magnitude was determined by the I-square (I^2). Heterogeneity was considered low when $I^2<50\%$, moderate when $I^2\geq50\%$ and $\leq75\%$, and high when $I^2>75\%$.[18] Prediction intervals were not used in each meta-analysis owing to the small number of studies.

In all analyses, a p-value <0.05 was considered statistically significant. Analyses were performed in the R Studio software, version 4.1.0 (R: A Language and Environment for Statistical Computing, Vienna, Austria), by using the 'Meta' packages, versions 5.0-0.

RESULTS

Our search retrieved 1,445 studies in the databases MEDLINE (via PubMed), Embase, BVS, LILACS, and BDENF. After excluding 377 duplicates, 1068 titles and abstracts were screened. In the textual analysis stage, 84 articles were carefully assessed. Of these, 76 were excluded according to the eligibility criteria described by the supplementary material, and the rest were eligible and included in systematic reviews and meta-analyses (n = 8). [**Supplementary Information (SI)**]. **(Figure 1)**

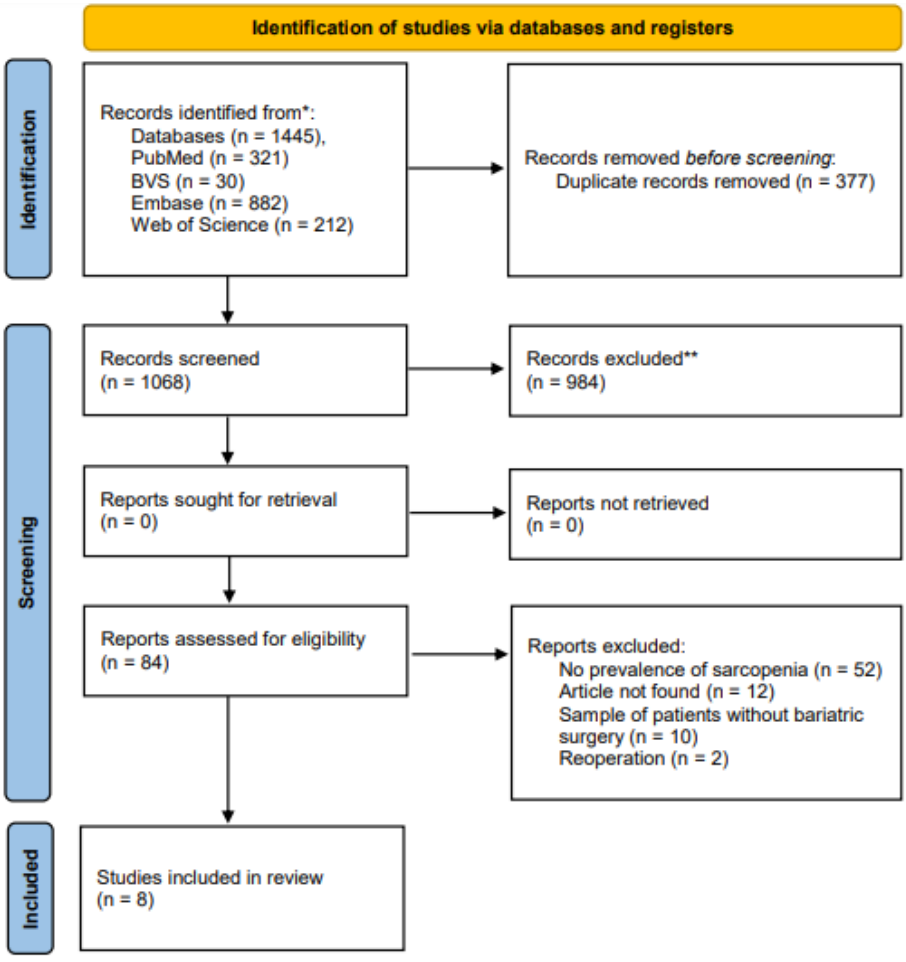

Fig. 1 Study selection flowchart

Regarding the sarcopenia after bariatric surgery outcome, we observed that five studies (62.5%) were identified as having a moderate risk of bias, and 3 (37.5%) had a high risk of bias, scoring 6 and 5 points, respectively. The risk of bias for each study is described in the **Supplementary Information (SI).**

Studies characteristics

The main characteristics of the included studies are summarized in **Table 1**. In total, eight studies evaluating sarcopenia after bariatric surgery were included. According to the study design, 7 (87.5%) were cohort studies, and one (12.5%) was a cross-sectional study. It is worth mentioning that no studies were found on randomized or nonrandomized phase I. The study population included 442 individuals, of whom 347 (78.51%) were female and 95 (21.49%) were male. The mean age was 42.29 ± 10.30 years.

Table 1. Characteristics of the included studies

Authors (Year)	Country(ies)	Study design	Type of surgery	Definition of sarcopenia	Data collection methods
Carvalho et al., 2023 [4]	Brazil	Prospective cohort	Mixed	Generalized loss of skeletal muscle mass and function associated with SMI.	BIA
Vassilev et al., 2022 [19]	Germany	Prospective cohort	RYGB	Generalized loss of skeletal muscle mass and function associated with SMI.	BIA
Khitaryan et al., 2021 [20]	Russia	Cross sectional	Mixed	Generalized loss of skeletal muscle mass and function associated with SMI.	BIA
Santarpia et al., 202 [21]	Italy	Prospective cohort	Mixed	Generalized loss of skeletal muscle mass and function associated with SMI.	DXA
Speranza et al., 2020 [22]	Italy	Prospective cohort	Mixed	Reduction in fat-free mass associated with SMI.	BIA
Pekař et al., 2020 [23]	Czech republic	Prospective cohort	Mixed	Association of indices: Fat Mass Index, Lean Mass Index and Appendix Lean Mass Index.	DXA
Maimoun et al., 2019 [24]	France	Prospective cohort	SG	Generalized loss of skeletal muscle mass and function associated with SMI.	Anthropometry
Voican et al., 2018 [25]	France	Prospective cohort	SG	Generalized loss of skeletal muscle mass and function associated with SMI.	Anthropometry

Legend: Roux-en-Y gastric bypass (RYGB); Sleeve gastrectomy (SG); Mixed: Includes more than one type of bariatric; Skeletal Muscle Mass Index (SMI); Dual-energy X-ray absorptiometry (DXA), Bioelectrical Impedance Analysis (BIA).

According to the data collection methods, 4 (50%) used BIA, 2 (25%) used DXA, and 2 (25%) used anthropometry. Recent studies (within 1 year) represent 12.5% of the sample (n=1), and studies from 2 years to 5 years represent 87.5% (n=7).

Meta-analysis

The results found in this meta-analysis indicated that the highest prevalence of sarcopenia was observed in 17 individuals who underwent RYGB surgery, 59% (95% CI: 33.0–82%) had sarcopenia (I^2=97%). Among 214 individuals who underwent SG, 18% (95% CI: 0.0–46%) had sarcopenia (I^2=97% [93%; 99%]; p<0.01). Among studies that analyzed other associated surgical techniques, 33% of 211 individuals (95% CI: 3.0–64%) had sarcopenia (I^2 = 98% [96%; 98%]; p < 0.01). **(Figure 2)**

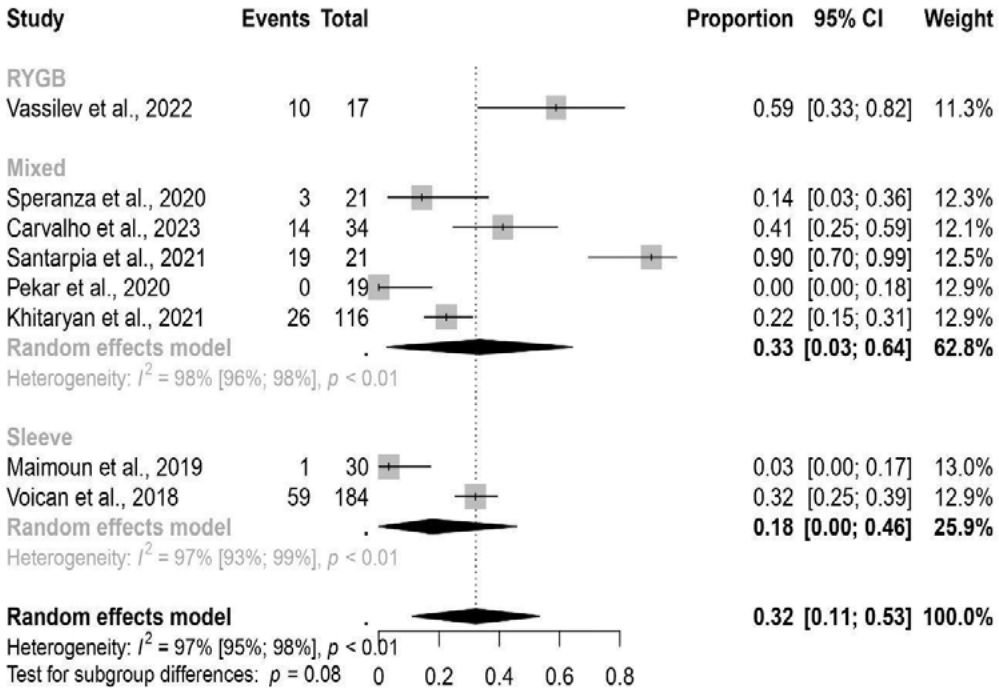

Fig. 2 Forest plot of the pooled prevalence ratio of sarcopenia assessment in people who underwent bariatric surgery by type of surgery, 2023.

Furthermore, a higher prevalence of sarcopenia was observed in cohort studies compared to cross-sectional studies (34% versus 22%) with high overall heterogeneity (I^2=97% [95.0%;98.0]; p<0.01). The pooled prevalence ratio demonstrated that 32% (95% CI: 11–53%) of individuals had sarcopenia after bariatric surgery. The heterogeneity was high (I^2= 97% [95.0%;98.0%]; p < 0.01). **(Figure 3)**

Regarding the data collection methods, it was observed that the assessment of sarcopenia by DXA (n=2) had a higher at 45% (95% CI: 0.0–100%) compared to other methods, with significant heterogeneity (I^2=99% [99.0%; 100 %]; p < 0.01). Other data collection methods, such as BIA (n=4) and anthropometry (n=2), had sarcopenia prevalence of 32% (95% CI: 14.0–51%) and 18% (95% CI: 0.0–46%), respectively. All methods exhibited high heterogeneity, with BIA I^2 values of 79% [42%; 92%] (p<0.01), and anthropometry with I^2=97% [93%; 99%] (p<0.01)**. (Figure 4)**

When analyzing the time since surgery, individuals who underwent bariatric surgery more than a year ago (n=3) exhibited a higher sarcopenia prevalence of 55% (95% CI: 10.0–99.0%), with significant heterogeneity (I^2=97% [93.0%; 98.0%]; p < 0.01), compared to those who had the surgery less than 1 year with 03% (95% CI: 0.0–17%) and 1 year with 24% (95% CI: 0.0–48%), all displaying high heterogeneity above I^2=96% [92%; 98%] (p<0.01). **(Figure 5)**

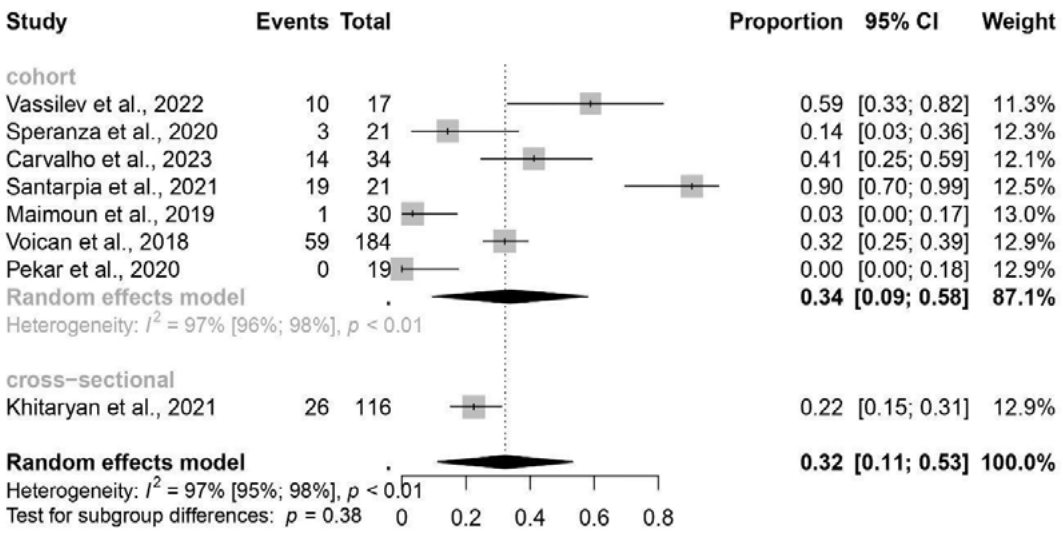

Fig. 3 Forest plot of the pooled prevalence ratio of sarcopenia assessment in people who underwent bariatric surgery by study design, 2023.

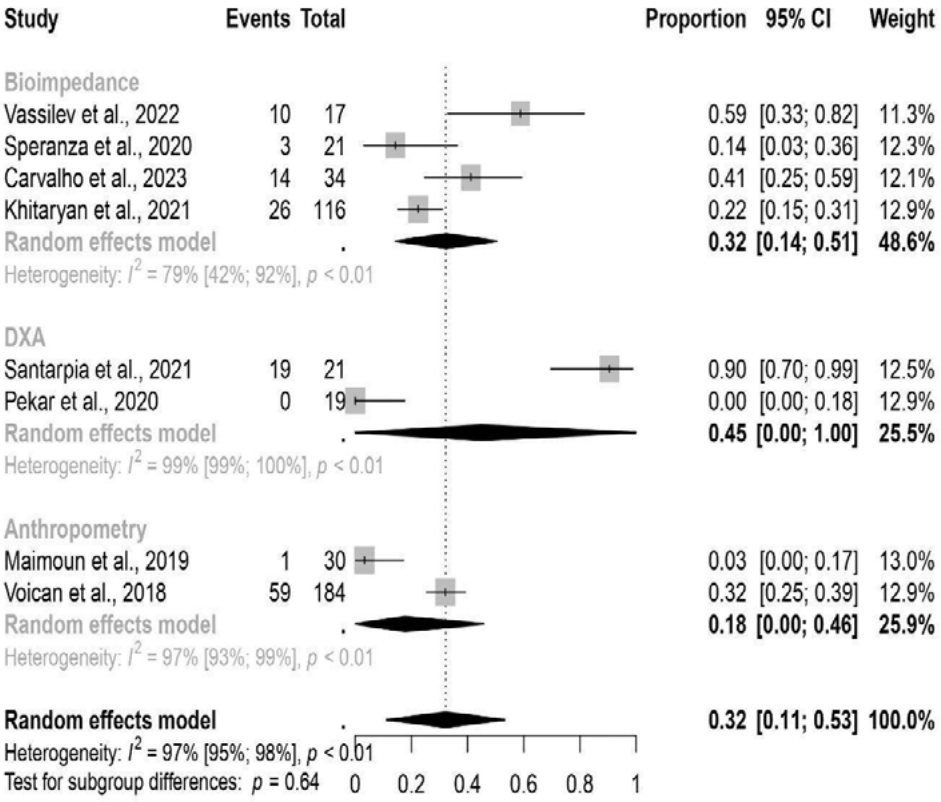

Fig. 4 Forest plot of the pooled prevalence ratio of sarcopenia assessment in people who underwent bariatric surgery by data collection methods, 2023.

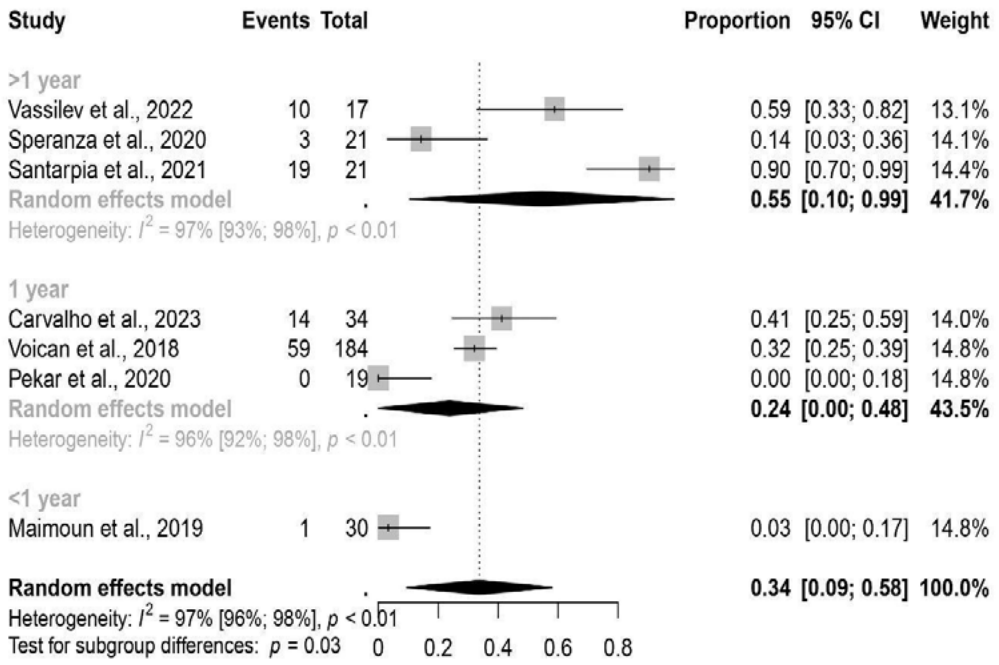

Fig. 5 Forest plot of the pooled prevalence ratio of sarcopenia assessment in people who underwent bariatric surgery by time since surgery, 2023.

DISCUSSION

This systematic review with meta-analysis demonstrated that 32% of individuals had sarcopenia after bariatric surgery, and this prevalence is higher in those who underwent RYGB surgery (59%) and time of surgery more than a year ago (55%), despite having been evaluated in only one and three studies, respectively and DXA as most prevalent data collection methods (45%).

Cohort studies demonstrated a higher percentage (34%) of sarcopenia, thus allowing interpretations related to the fundamental issue of temporality, which cannot be identified in cross-sectional studies (22%).[26] This is associated with the analysis of the follow-up period, where studies lasting more than one year also showed higher rates of sarcopenia. According to Santos et al. (2023),[27] in the first year after bariatric surgery, due to intense anabolic processes adapting to surgical modifications, the body requires more significant interventions to prevent muscle mass loss and promote protein synthesis. However, after two years, these changes in body composition face more significant interferences, not only related to surgery but also to the lack of maintenance of a healthy lifestyle and complications arising from the development of other diseases, such as osteoporosis, that contribute to the occurrence of sarcopenia.

While evaluating the time since surgical performance is necessary, analyzing from the perspective of the surgical type also has a significant impact on the presented sarcopenia results, the RYGB technique showed a higher percentage (59%) of sarcopenia compared to sleeve gastrectomy (SG) (18%). Therefore, RYGB tends to increase the loss of muscle and bone mass to a greater extent, influenced by greater weight loss, malabsorption of nutrients, and other hormonal changes,

which do not occur in the same way in restrictive surgeries such as SG.[28]

Thus, according to the methods used, BIA showed a lower prevalence compared to DXA. DXA is considered the gold standard for body composition analysis in the literature,[29-30,] and not only that, but BIA tends to overestimate data for lean body mass, fat mass, and percentage of body composition.[31] This is reflected in the analysis of results, showing worse effectiveness and evidence in identifying sarcopenic individuals in the studies evaluated using this method.

The consideration that sarcopenia is a condition directly associated with age, mainly due to the decrease in muscle mass and gradual decline in muscle protein synthesis, contradicted what was found in our study.[32] This could be seen from the higher number of sarcopenia cases found in the mean age 42.29 ± 10.30 years population, identifying that bariatric surgery is a significant influencing factor greatest impact in the development of sarcopenia, and age is not necessarily always considered a cause but one of the conditions that can contribute to the development of sarcopenia.[33]

Research validity and limitations

One of the main strengths of our study is that, by systematically analyzing the literature and understanding the prevalence estimate of sarcopenia, we contribute to the important discussion of possible consequences related to the nutritional parameters involved in the bariatric techniques.

An important limitation of this review was that most of the studies presented a moderate risk of bias, with 62.5% indicating adequacy in several critical methodological aspects while also suggesting gaps in areas such as proper sampling, sample size, and detailed descriptions of subjects and study settings. Specifically, three studies [20-22] had individual scores below 60%, reflecting a higher risk of bias that may compromise the robustness of the meta-analysis findings. These methodological deviations, along with the observed uncertainties, should be considered when interpreting the analysis results. The influence of these biases on the overall conclusions of the study is significant, as they may limit the generalizability of the findings and increase the heterogeneity of the results.

In addition, while the number of selected studies was not large, it still allowed for a comprehensive analysis. However, no studies enabled us to assess the factors associated with sarcopenia and bariatric surgery.

CONCLUSION

The post-surgical performance of bariatric surgery has a major impact on the risk of sarcopenia, as observed in the prevalence of 32% in bariatric sarcopenic individuals. Therefore, it can be concluded that sarcopenia has been evidenced in this population and deserves the necessary attention from health professionals for its prompt screening, intervention, and post-operative follow-up. Furthermore, it is recommended that future research adopt larger samples and more rigorous methodologies to minimize such risks and provide more robust and reliable evidence. Additionally, studies should aim to understand the associated factors and identify necessary interventions to prevent the development of sarcopenia in this population, as well as how these interventions could impact public health on a large scale.

SUPPLEMENTARY INFORMATION (SI).

S1. Search Strategy
S2. Table. Excluded studies
S3. Risk of Bias

AUTHOR CONTRIBUTIONS

NSG and MGR developed the study's concept and projected it. Direct access to MGR, PIC, and NSG; data verification and analysis. MGR and NSG wrote the first paragraph of the manuscript. All authors contributed to the data inter-

pretation, reviewing, and editing of the manuscript. NSG oversaw the research process. All of the authors had complete access to all of the study's data and were ultimately responsible for the decision to submit them for publication.

DATA AVAILABILITY STATEMENT

This study used data that was made available on public websites and electronic data banks. The Brazilian government gained access to the Embase platform (via the CAPES website).

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THE AUTHORS DECLARE THAT THERE IS NO CONFLICT OF INTERESTS IN RELATION TO THIS ARTICLE.

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