Meta-Analysis

Nutritional and exercise interventions in individuals with sarcopenic obesity around retirement age: a systematic review and meta-analysis

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Context: *Retirement is an opportune time for people to establish new healthy routines. Exercise and nutritional interventions are promising in the prevention and treatment of sarcopenic obesity.* ***Objective:*** *This systematic review aimed to assess the effectiveness of nutritional and exercise interventions for the treatment of sarcopenic obesity in persons of retirement age.* ***Data Sources:*** *PubMed, Embase, CINAHL, and CENTRAL databases were searched in September 2021 for randomized controlled trials; a manual search was also conducted. The search yielded 261 studies, of which 11 were eligible for inclusion.* ***Data Extraction:*** *Studies of community-dwelling individuals with sarcopenic obesity receiving any nutritional or exercise intervention $\geq$ 8 weeks with the mean age $\pm$ standard deviation between 50 and 70 years were included. Primary endpoint was body composition, and secondary endpoints were body mass index, muscle strength, and physical function. The literature review, study selection, data extraction, and risk-of-bias assessment were performed by two reviewers independently. Data were pooled for meta-analysis when possible.* ***Results:*** *Meta-analysis was only possible for the exposure "resistance training" and the exposure "training (resistance or aerobic)" in combination with the exposure "added protein" as compared with "no intervention" or "training alone." Resistance training led to a significant body fat reduction of −1.53% (95%CI, −2.91 to −0.15), an increase in muscle mass of 2.72% (95%CI, 1.23–4.22), an increase in muscle strength of 4.42 kg (95%CI, 2.44–6.04), and a slight improvement in gait speed of 0.17 m/s (95%CI, 0.01–0.34). Protein combined with an exercise intervention significantly reduces fat mass (−0.80 kg; 95%CI, −1.32 to −0.28). Some individual studies of dietary or food supplement interventions for which data could not be pooled showed positive effects on body*

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composition. ***Conclusion:*** *Resistance training is an effective treatment for persons of retirement age with sarcopenic obesity. Increased protein intake combined with exercise may increase reductions in fat mass.*
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INTRODUCTION

Aging is associated with changes in body composition, with fat mass typically increasing until about the seventh decade of life and, simultaneously, muscle mass decreasing from about the fifth decade of life onward.[1–3] As a result, the risk of older individuals to develop obesity, defined as abnormal or excessive fat accumulation, as well as sarcopenia, defined as the progressive and generalized loss of muscle mass and function, is high.[3] About 60% of older Europeans are overweight, and about 20% are obese.[4] At the same time, literature has shown that sarcopenia is present in 13% to 40% of older adults across different regions of the world. The prevalence of sarcopenic obesity increases steeply with age, varies between ethnicities and sex, and depends on the underlying definition of sarcopenic obesity.[5–7]

Several different definitions of sarcopenia and sarcopenic obesity are available. Definitions from the International Working Group on Sarcopenia, the European Working Group on Sarcopenia in Older People, and the Asian Working Group for Sarcopenia are widely used.[8–10] Recently, the European Society for Clinical Nutrition and Metabolism and the European Association for the Study of Obesity published an expert consensus on the definition and diagnostic criteria for sarcopenic obesity, but these recommendations have not yet been implemented into research and practice.

Both obesity and sarcopenia lead to serious negative outcomes that are exacerbated when both conditions are present simultaneously. The comorbid presence of obesity and sarcopenia increases the risk of disability, immobility, care dependency, and negative health outcomes that include dyslipidemia, insulin resistance, osteoarthritis, falls, fractures, and lower quality of life.[3,11–14] Sarcopenic obesity has been shown to be a predictor of disability more accurately than obesity or sarcopenia alone.[11] Data from the National Health and Nutrition Examination Survey cohort for a US population with a mean age of 71 years shows a prevalence of sarcopenic obesity of 33.5% in women and 12.6% in men.[7] A recent systematic review found a global prevalence of 11% of sarcopenic obesity among older community-dwelling adults.[15]

Since muscle mass decreases from 50 years of age onward and fat mass increases up to 70 years of age, this time frame of age offers great potential for the prevention and treatment of sarcopenic obesity. This is also the time when most individuals enter retirement. As a result, the transient time of retirement can be seen as a window of opportunity to improve lifestyle behavior and treat sarcopenic obesity as well as to limit the onset of sarcopenic obesity. Persons in the retirement phase usually need to restructure their daily activities and may be motivated to establish new healthy routines that can prevent dependency and disabilities in later life.[16]

The optimal approach to treat or limit the onset of sarcopenic obesity and the associated negative health outcomes is to reduce fat mass while simultaneously preserving muscle mass, strength, and physical function. Nutrition and exercise interventions are the two of the most promising strategies in the management of sarcopenic obesity.[17–19] A literature review of available systematic reviews identified 5 systematic reviews that provide information about the effectiveness of exercise and nutritional interventions on sarcopenic obesity in older adults or in adults in general.[20–24] None of these systematic reviews focused solely on persons of retirement age, and meta-analysis was performed in only 3 of them. The identification of effective exercise and nutritional interventions enables healthcare practitioners to make recommendations to people of retirement age affected by sarcopenic obesity as well as to develop preventive strategies. Therefore, the aim of this systematic review and meta-analysis was to comprehensively answer the following research question: Which type of nutritional and exercise interventions are effective for the treatment of sarcopenic obesity in persons of retirement age? For this study, an age range of 50 to 70 years, which includes the usual age of retirement, was defined.

METHODS

To answer the research question, a systematic review of randomized controlled trials (RCTs) was performed, and meta-analyses were conducted where possible. This systematic review was registered in the PROSPERO database (no. CRD42021276461). The review protocol is available at https://www.crd.york.ac.uk/prospero/. No substantial methodological changes were made to the registered protocol. This systematic review was reported according to the 2020 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.[25] The PRISMA checklist is available as Table S1 and the PRISMA 2020 checklist as Table S2 in the Supporting Information online.

Search strategy

A comprehensive literature search of the following databases was conducted to identify RCTs published up to September 16, 2021: PubMed (MEDLINE) from 1946 onward, Embase via OVID from 1974 onward, CINAHL via EBSCOhost, and the Cochrane Central Register of Controlled Trails (CENTRAL) in the Cochrane Library. Two trial registers (clinicaltrials.gov and the WHO International Clinical Trials Registry Platform) were also searched, and the reference lists of eligible articles (ie, snowballing), as well as Google Scholar, were checked to identify additional potentially relevant studies. The literature review was conducted by two authors independently. There were no restrictions on language.

The following search terms were used to identify relevant studies: "obesity," "sarcopenia," "sarcopenic obesity," "utr*," "oral nutritional supplements," "diet," "train*," "physical activity," "exercise," and the MeSH terms "diet, food, and nutrition," "nutrition therapy," "diet," and "exercise." The search terms were combined using the Boolean operators AND and OR. Small adaptations were applied to the searches conducted in Embase, CINAHL, and CENTRAL. The specific search strategies used for each database are shown in Appendix S1 in the Supporting Information online.

Study selection

Study selection was carried out with the Covidence systematic review software (Veritas Health Innovation; Melbourne, Australia). Title and abstract screening as well as full-text screening was conducted by two authors independently (D.E., M.T, S.B.). In case of conflicts, a consensus was reached by discussion and, if necessary, a third author was consulted to make a final decision (D.E.). Articles were included on the basis of predefined PICOS (Participants, Intervention, Control, Outcomes, Study design) criteria (Table 1). Conference abstracts were excluded. Primary endpoints were body composition (eg, body fat mass, muscle mass, lean mass). Secondary endpoints were body mass index, muscle strength, and physical function (eg, gait speed). Studies in which any pharmaceutical agent was administered were excluded.

Table 1 **PICOS criteria for inclusion of studies**

Parameters	Inclusion criteria
Participants	Community-dwelling persons with sarcopenia and obesity for whom the mean age, together with the standard deviation, did not surpass 50–70 years at baseline
Intervention	Any nutritional and/or exercise intervention with a duration of at least 8 weeks
Control	No intervention
Outcomes	Body composition (eg, fat mass, muscle mass, lean mass), body mass index, muscle strength, physical functioning
Study design	Randomized controlled trials

Data extraction and quality assessment

For the purpose of data extraction, a standardized data extraction template, which included study characteristics, patient characteristics, and outcomes, was used. Two independent reviewers (D.E., M.T.) extracted data from the full-text articles that were included. The methodological quality of the RCTs was assessed by two authors independently, using the Cochrane Risk of Bias Tool.[26] Use of this tool enabled the following potential sources of bias to be evaluated: sequence generation; allocation concealment; blinding of participants, personnel, and outcome assessment; incomplete outcome data; selective outcome reporting; and other sources of bias.

Data synthesis and data analysis

The data synthesis and data analysis processes in this study were carried out as recommended in the *Cochrane Handbook for Systematic Reviews of Interventions*.[26] Comparable studies were grouped on the basis of the type of intervention. Meta-analysis was conducted when at least two comparable studies were identified for the respective intervention and outcome. An intention-to-treat analysis of the primary studies was preferred, if available. If there were considerably different measurement methods for one outcome, subgroup analyses were performed. For interventions for which data could not be pooled, results were summarized narratively.

The statistical analysis was conducted with Review Manager software (version 5.4.1; Cochrane, Oxford, UK). The primary outcome was the mean difference (MD) in postintervention body composition (fat mass and muscle mass) between the intervention group and the control group. Continuous outcome data were presented as mean differences with standard deviations

(SDs) (ie, intervention group minus control group) and 95% confidence intervals.

For trials with more than one control group, the control group without any intervention was included. Random-effects models were used to calculate the overall estimated weighted mean differences. The statistical heterogeneity of the included studies was assessed using the X^2 test (statistical significance was set at $P < 0.05$) and I^2 statistics. An I^2 value up to 25% was assumed to indicate low heterogeneity, a value up to 50%, moderate heterogeneity, and a value more than 75%, high heterogeneity among the studies.[27] Reporting bias was evaluated by funnel plots if more than 10 studies were available.

RESULTS

Characteristics and quality of the included studies

The literature search resulted in the identification of 261 records, of which 85 were duplicates. Title and abstract screening was conducted for 176 studies. Of these, 115 were excluded on the basis of title and abstract screening after the predefined inclusion and exclusion criteria were applied. The remaining 61 articles were assessed for eligibility by full-text screening, which yielded 11 studies that were eligible for inclusion in the systematic review. The flow diagram of the literature search process is shown in Figure 1.[25]

The characteristics of the 11 included studies are summarized in Table 2.[28–38] The sample size ranged from 18 to 111 participants. Six studies assessed the effectiveness of exercise interventions,[29–32,36,38] 2 studies assessed different nutritional interventions,[28,37] and 3 studies evaluated the effect of a nutritional intervention in combination with training.[33–35] One study included only men, and 9 studies, only women. The duration of the interventions varied between 8 and 24 weeks. Adherence to the interventions was reported in 5 studies and ranged between 85% and 97.6%. Two studies (Huang et al[31] and Liao et al[32]) included some of the same participants but reported partly different outcomes. Primarily, the study of Liao et al[32] was used for conducting meta-analyses, as it included more participants. However, if there was an outcome that was reported only in the pilot study (Huang et al[31]), the data from that publication were used.

The quality of the individual studies is shown in Figure 2.[28–38] In general, the risk of bias was rather low. Blinding of the participants was not possible in most of the included studies because of the nature of the intervention. If no derivation of the intended intervention was obvious and it was assumed that the assigned intervention did not impact the outcome, a low risk of bias was assessed. Even if the number of studies was too low to create funnel plots, no indication of reporting bias was detected.

The heterogeneity of the studies included in the meta-analyses was mostly low to moderate. Only the meta-analysis for the effect of resistance training on gait speed displayed high heterogeneity between the included studies. Therefore, the results for the outcome of gait speed must be interpreted with caution.

Interventions

Of the 11 studies included in this systematic review, 3 different exercise interventions were identified, namely, resistance training, aerobic training, and a combination of resistance and aerobic training. In most of the studies (n = 4), resistance training was performed with the help of elastic bands (Thera-Band). The benefit of training (resistance or aerobic) in combination with added protein intake (either as a supplement after the resistance training sessions or a higher natural protein content of the whole diet) was investigated in 3 studies.[33–35] Nutritional interventions alone were investigated in 2 studies. These interventions differed considerably and included supplementation with isoflavones[30] and a hypocaloric diet with increased protein content.[37]

Meta-analysis for the effect of resistance training

The effects of resistance training were examined in 6 trials.[29–32,36,38] Frequency of the training was 2 to 3 times a week, and the duration ranged from 20 to 60 minutes per session. The results of the meta-analysis for all outcomes are shown in Figure 3.[29–32,36,38]

Percent body fat. Four studies with a total of 198 participants reported results for the effects of resistance training on percent body fat; therefore, these could be pooled.[29–32,36] The meta-analysis results reveal a significant reduction in percent body fat (MD −1.53%; 95%CI, −2.91 to −0.15) through resistance training. The I^2 of the data was 28%, indicating a moderate level of heterogeneity between the studies.

Muscle mass. Muscle mass in kilograms was reported in 3 studies with a total of 136 participants, and muscle mass as a percentage of body weight was reported in 2 studies with 88 participants. Resistance training had a statistically significant effect on muscle mass (pooled treatment effect: MD 2.72%; 95%CI, 1.23–4.22). No effect was observed on muscle mass when measured in kilograms (MD −0.01 kg; 95%CI, −0.98 to 0.96). The heterogeneity between studies included in the analysis was

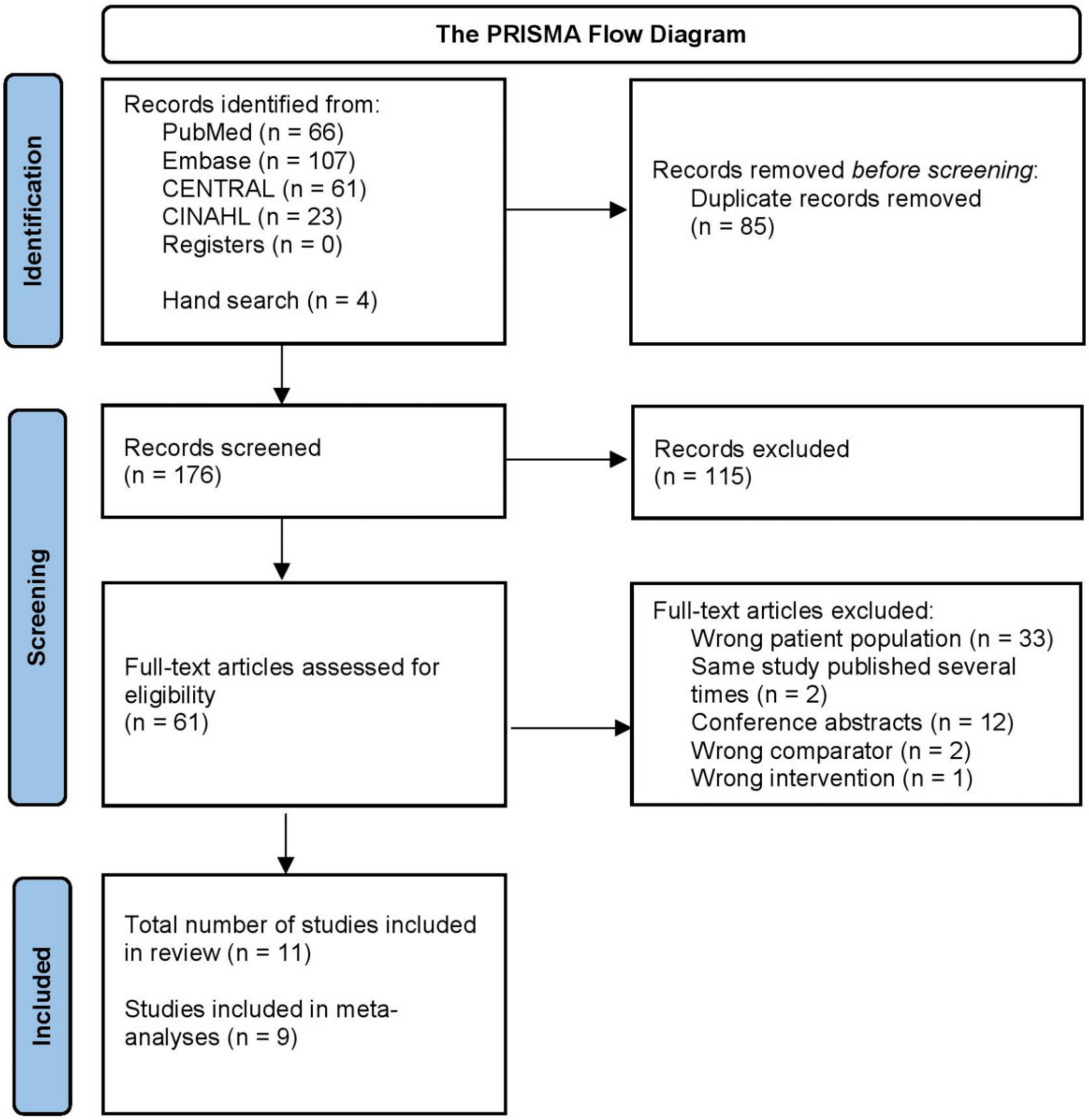

Figure 1 **Flow diagram of the literature search process.**[25]

low, with an I^2 of 0% for muscle mass as a percentage of body weight and 11% for muscle mass in kilograms.

Body mass index. Three studies with a total of 127 participants investigated the effect of resistance training on body mass index (BMI).[29–31] The results of the meta-analysis showed no significant effect (MD -0.57 kg/m^2; 95%CI, -1.91 to 0.77; $I^2 = 0\%$).

Muscle strength. To determine muscle strength, 3 studies measured hand grip strength[30,32,36] and 1 study measured knee extensor strength.[38] A subgroup analysis by type of measurement was conducted. The meta-analysis of all 4 studies ($n = 164$ total participants) showed that resistance training, when compared with no training, significantly improved muscle strength (MD 4.42 kg; 95%CI, 2.44–6.04). The I^2 was 44%, which indicates moderate heterogeneity between studies.

Gait speed. Three studies investigated the effect of resistance training on gait speed.[32,36,38] The meta-analysis showed a significant improvement in gait speed; however, the heterogeneity between studies was very high (MD 0.17 m/s; 95%CI, 0.01–0.34; $I^2 = 85\%$; $P < 0.001$).

Meta-analysis for the effect of training plus increased protein intake

The effects of training in combination with increased protein intake were examined in 3 trials.[33–35] Two trials added a protein drink after the training sessions (whey and milk protein),[33,35] and 1 trial implemented an

Table 2 **Characteristics of the included studies (n = 11)**

Reference; country	Criteria for diagnosis of sarcopenic obesity		Mean age ± SD	Sex	Sample size (N)	Intervention	Tool used to assess body composition	Duration of intervention	Adherence
	Sarcopenia	Obesity							
Chen et al (2017)[30]; Taiwan	SMI (ASM/BW): M: ≤ 32.5% F: ≥ 27.7%	BMI ≥ 25 kg/m^2 VFA ≥ 100 cm	68.8 ± 3.3 y	M (20%), F (80%)	N = 60 AT = 15 RT = 15 CT = 15 CG = 15	Exercise (4 arms): 1. RT: 60%–70% of 1 RM 2×/wk for 60 min/session 2. AT: 2×/wk for 60 min/session 3. CT: 1×/wk (AT 48 h after RT) 4. CG: day-to-day lifestyle	BIA	8 wk	NR
Huang et al (2017)[31]; Taiwan	SMI (TSM/BW) < 27.6%	Body fat > 30%	69.2 ± 5.0 y	F	N = 35 IG = 18 CG = 17	Exercise (2 arms): 1. RT: elastic band training 3×/wk, 55 min/session 2. CG: health education	DXA	12 wk	NR
Liao et al (2018)[32]; Taiwan	SMI (TSM/BW) < 27.6%	Body fat > 30%	67.3 ± 5.1 y	F	N = 53 IG = 30 CG = 23	Exercise (2 arms): 1. RT: elastic band training, 3×/wk for 55 min/session 2. CG: no intervention	BIA	12 wk	97.6%
Park et al (2017)[36]; Korea	SMI (ASM/BW) < 25.1%	BMI > 25 kg/m^2	74.1 ± 6.1 y	F	N = 50 IG = 25 CG = 25	Exercise (2 arms): 1. RT: elastic band exercise 20–30 min/session 3×/wk + AT 30–50 min/session 5×/wk 2. CG: usual physical activity	BIA	24 wk	92%
Vasconcelos et al (2016)[38]; Brazil	GS ≤ 21 kg	BMI ≥ 30 kg/m^2	72.0 ± 4.1 y	F	N = 28 IG = 14 CG = 14	Exercise (2 arms): 1. RT: high-speed intervention 2×/wk for 1 h/session 2. CG: monitored by therapists 1×/wk by phone	NR	10 wk	85%
Banitalebi et al (2021)[29]; Iran	SMI < 27.6%	Body fat > 30%	68.0 ± 5.09 y	F	N = 35 IG = 18 CG = 17	Exercise (2arms): 1. RT: elastic band training 3×/wk 2. CG: typical diet and activity habits	DXA	12 wk	85%
Aubertin-Leheudre et al (2007)[28]; Canada	SMI < 6.87 kg/m^2	Body fat > 40%	58.0 ± 5.0 y	F	N = 24 IG = 14 CG = 10	Nutrition (2 arms): 1. 4 capsules daily: 70 mg/d isoflavones 2. CG: placebo	DXA	15 wk	NR
Sammarco et al (2017)[37]; Italy	< 90% of fat-free mass	Body fat > 34.8%	55.0 ± 9.6 y	F	N = 18 IG = 9 CG = 9	Nutrition (2 arms): 1. IG: hypocaloric + high protein 2. CG: hypocaloric + placebo	BIA	16 wk	NR

(continued)

Table 2 **Continued**

Reference; country	Criteria for diagnosis of sarcopenic obesity		Mean age ± SD	Sex	Sample size (N)	Intervention	Tool used to assess body composition	Duration of intervention	Adherence
	Sarcopenia	Obesity							
Maltais et al (2016)[33]; Canada	SMI (ASM/ht^2) < 10.75 kg/m^2	BMI > 30 kg/m^2	65.2 ± 4.8 y	M	N = 26 IG1 = 8 IG2 = 8 CG = 10	Exercise + nutrition (3 arms): 1. IG1: milk powder (14 g protein) + RT 3×/wk for 1 h/session 2. IG2: commerical EAA powder (12 g protein) + RT 3×/wk for 1 h/session 3. CG: RT 3×/wk for 1 h/session	BIA–SECA	16 wk	> 90%
Muscariello et al (2016)[34]; Italy	SMI (TSM/ht^2) < 7.3 kg/m^2	BMI > 30 kg/m^2	66.7 ± 4.9 y	F	N = 104 IG = 50 CG = 54	Nutrition + exercise (2 arms): 1. Hypocaloric diet and NPI: 0.8 g protein/kg DBW/d + AT: 5×/wk for 30 min 2. Hypocaloric diet and HPI: 1.2 g protein/kg DBW/d +AT: 5×/wk for 30 min	BIA	12 wk	NR
Nabuco et al (2019)[35]; Brazil	ASM < 15.02 kg	Body fat > 35%	69.0 ± 4.1 y	F	N = 26 IG = 13 CG = 13	Exercise + nutrition (2 arms): 1. IG: WP + RT 3×/wk 2. CG: RT 3×/wk + maltodextrin	DXA	16–12 wk	NR

Abbreviations: ASM, appendicular skeletal mass; AT, aerobic training; BIA, bioelectrical impedance analysis; BMI, body mass index; BW, body weight; CG, control group; CT, combined training; DBW, desirable body weight; DXA, dual-energy x-ray absorptiometry; EAA, essential amino acids; F, female; GS, gait speed; HPI, high protein intake; ht^2, height^2; IG, intervention group; M, male; NPI, normal protein intake; NR, not reported; RM, repetition maximum; RT, resistance training; SD, standard deviation; SMI, skeletal muscle index; TSM, total skeletal muscle mass; VFA, visceral fat accumulation; WP, whey protein.

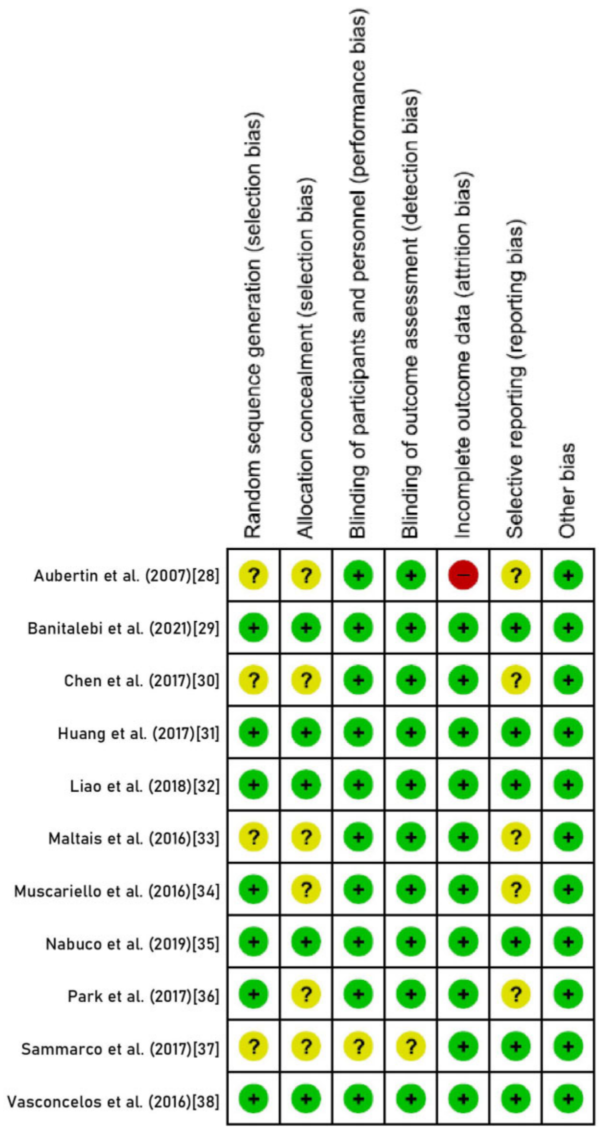

Figure 2 **Risk-of-bias summary.**

increased protein intake of 1.2 g/kg of desirable body weight per day (vs 0.8 g/kg of desirable body weight per day in the control group).[34] The results of meta-analysis for the reported outcomes are shown in Figure 4.[33–35] A subgroup analysis was conducted because of the heterogeneity of the interventions.

Fat mass in kilograms. Three studies with a total of 148 participants investigated the effect of added protein plus exercise on fat mass in kilograms.[33–35] The results of the meta-analysis show a statistically significant difference in the reduction of absolute fat mass between the intervention group and the control group (MD −0.80 kg; 95%CI, −1.32 to −0.28; $I^2 = 0\%$).

Lean mass. A meta-analysis was conducted with 3 studies and 148 participants.[33–35] No effect of added protein on lean body mass could be detected (MD 0.14 kg; 95%CI, −0.81 to 1.10; $I^2 = 0\%$).

BMI and waist circumference. Two studies with a total of 122 participants reported the effects of added protein intake on BMI.[33,34] A tendency toward reduced BMI in the protein group was observed, but the difference between the intervention and control group was not significant (MD −0.40 kg/m^2; 95%CI, −0.83 to 0.03; $I^2 = 0\%$). A meta-analysis for the effect of increased protein on waist circumference was also conducted with 2 studies and 130 participants[34,35]; no effects of added protein were shown (MD −0.12 cm; 95%CI, −1.24 to 1.00; $I^2 = 0\%$).

Other identified interventions. It was not possible to pool data for the interventions of aerobic training, combined aerobic and resistance training, isoflavone supplementation, or a hypocaloric diet with a high protein content. Therefore, the results of the single studies are summarized below.

Exercise. One study compared 3 different exercise groups—resistance training, aerobic training, and resistance plus aerobic training—with a control group.[31] Percent body fat decreased with resistance training as well as with aerobic training, but it decreased the most in the group that performed both exercise types, resistance and aerobic training combined. Skeletal muscle mass also improved significantly in all training groups. Body mass index decreased only in the training group that performed resistance and aerobic training combined. The strongest improvements in muscle strength were detected in the resistance training group.[30]

Nutrition. Aubertin-Leheudre et al[28] found that isoflavone supplementation (70 g/d) in postmenopausal women significantly improved leg fat-free mass ($P = 0.034$), appendicular fat-free mass ($P = 0.016$), and muscle mass index ($P = 0.037$), as assessed by dual-energy x-ray absorptiometry. Sammarco et al[37] investigated the effect of a high-protein, hypocaloric diet supplemented with essential amino acids, including leucine (15 g/d), as compared with a hypocaloric diet alone. Participants in both groups displayed decreases in weight, total body fat mass, and percent body fat ($P < 0.05$). Phase angle, which is associated with muscle mass, did not change significantly in either group. Participants in the hypocaloric diet group without protein supplementation lost significantly more lean body mass as compared with the high-protein group ($P < 0.05$). Waist, thigh, calf, and arm circumferences did not change in either group. Muscle strength improved only in the group that received protein supplementation ($P < 0.01$).

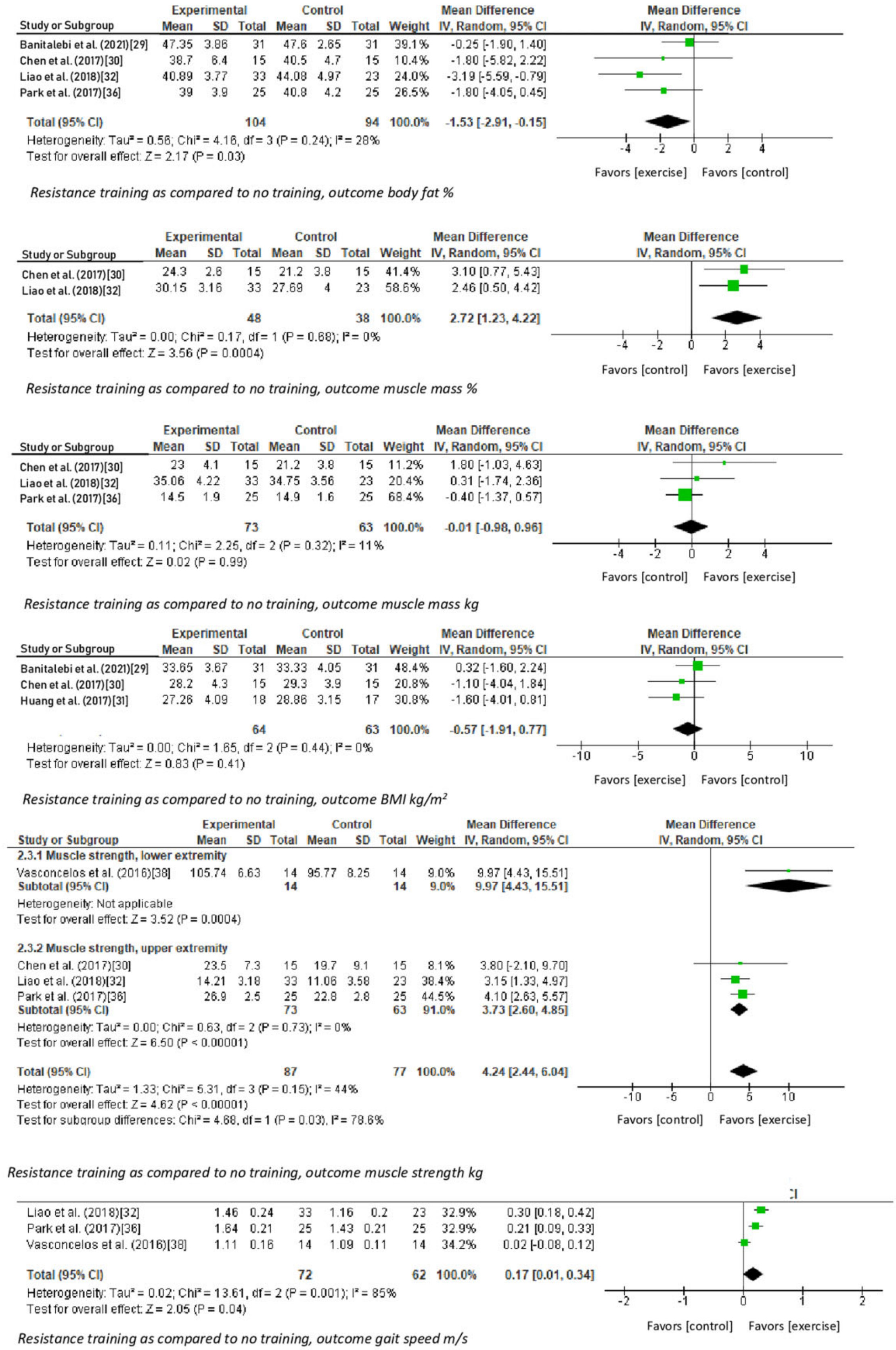

Figure 3 **Forest plots of comparisons between resistance training and no resistance training.**

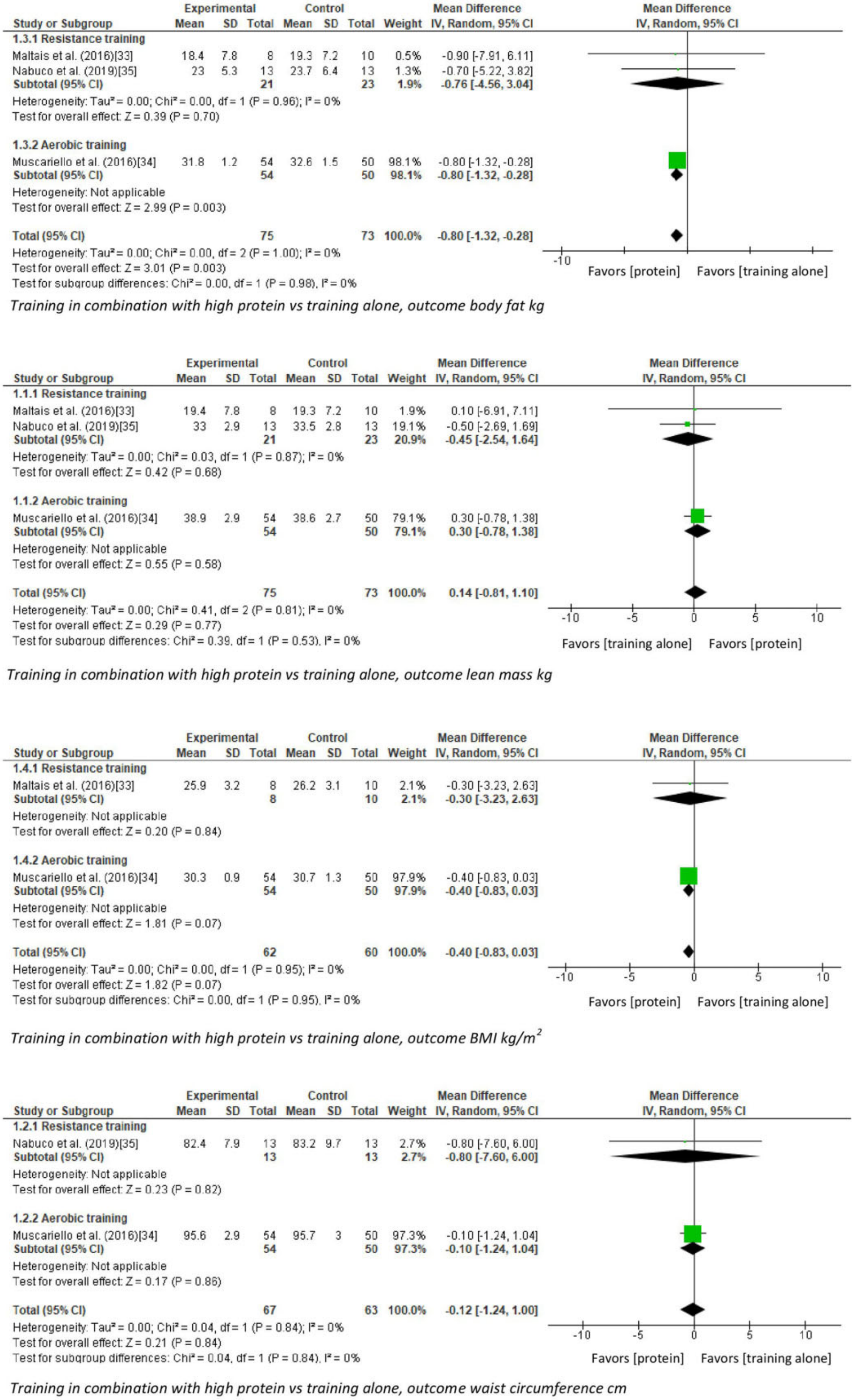

Figure 4 **Forest plots of comparisons between training in combination with high protein intake and training alone.**

DISCUSSION

The aim of this systematic review and meta-analysis was to summarize the nutritional and exercise interventions shown to be effective for the treatment of sarcopenic obesity in persons of retirement age (defined as persons 50 to 70 years of age). The results show that resistance training 2 to 3 times per week for 20 to 60 minutes effectively decreases percent body fat and increases percent muscle mass, muscle strength, and gait speed. Exercise in combination with increased protein intake reduced absolute body fat mass even more than training alone, especially when aerobic training was combined with increased protein intake.

The results should be interpreted not only with regard to significance but also to the clinical relevance for persons of retirement age with sarcopenic obesity. With resistance training, a body fat reduction of 1.53% was found. Increased protein intake in combination with training led to a 0.8-kg loss of body fat when compared with training alone. This is below the recommended 5% weight loss needed to improve comorbidities[39]. However, if this modest loss of body fat is combined with an increase in muscle mass, as shown in this systematic review, it may become clinically relevant. With regard to the impact of resistance training on muscle strength or gait speed, the improvements observed were near or within a clinically relevant range.[40,41]

The results of this systematic review support the results of prior systematic reviews conducted with other target groups (eg, older adults with sarcopenic obesity or persons of all ages with sarcopenic obesity), but only some of the same studies were included in the current review.[20,22–24] Some of these studies also found that exercise interventions led to improvements in body composition (increased muscle mass and decreased fat mass), grip strength, and walking speed.[20,22] As the results of this review also show, nutritional interventions in addition to exercise—such as a diet with higher protein content—did not demonstrate considerable advantages in terms of improved muscle mass or function, but they contributed to the reduction of fat mass.[20–22]

Very few studies have investigated the effects of nutritional interventions on sarcopenic obesity. Therefore, at this time, the evidence is too scarce to derive any recommendations for clinical practice. The studies in the present review were extremely heterogeneous in terms of the varying interventions used, the different definitions of sarcopenic obesity applied, and the varying outcomes investigated. Two of the studies followed the strategy of supplementing with milk or whey protein immediately after training sessions, which took place 3 times a week.[33,35] Supplementing with protein 3 times a week may not be enough. For example, Maltais et al[33] used a supplement containing 13.5 g of milk protein and 7 g of essential amino acids (which contained about 1.7 g of leucine). Studies show that about 3 g of leucine per day is needed to increase muscle protein synthesis in older adults, owing to an age-related state of anabolic resistance.[42,43]

Even though only a few available studies have investigated the effects of nutritional interventions on sarcopenic obesity, there is evidence that supplementation with protein/amino acids, in particular, helps to preserve muscle mass and function in older persons.[44] Randomized controlled trials in overweight and obese older adults (without coexisting sarcopenia) indicate that supplemental protein in combination with physical training is more effective in improving or preserving muscle mass and muscle strength than exercise alone.[45,46] A meta-analysis of RCTs revealed a significant increase in the rate of muscle protein fractional synthesis with leucine supplementation in older adults.[47] Another meta-analysis reported muscle mass gain in persons 65 years or older who received supplementation with β-hydroxy-β-methylbutyrate (a metabolite of leucine).[48] These findings raise the question of whether protein supplementation is effective in preventing sarcopenic obesity but possibly less effective in treating it. The previously mentioned studies did not specifically examine persons with sarcopenic obesity. However, nutritional interventions such as increasing dietary protein intake are clearly essential for reaching the treatment aims in individuals with sarcopenic obesity, namely, maintaining muscle mass and function and reducing fat mass.[7,49] At this time, however, it is difficult to make specific recommendations in terms of the protein amount, protein source, or timing of protein intake for preventing and treating sarcopenic obesity. It is also not clear which calorie deficit is effective, in the context of a hypocaloric diet, to achieve a reduction in fat mass while preserving muscle mass.[3] These aspects need to be clarified in future RCTs.

Another important issue in the identified studies is the lack of data on total protein intake, which includes dietary as well as supplemental protein. This is often not reported. Recommendations for healthy older adults are at least 1.0 to 1.2 g of protein per kilogram of body weight per day. For persons with acute or chronic illness, the ESPEN Expert Group recommends a protein intake of 1.2 to 1.5 g/kg/d.[44] In individuals with sarcopenic obesity, it is likely that inflammatory processes, other myocellular mechanisms, or hormonal changes, as well as the presence of chronic diseases and pathological processes, lead to higher protein needs to maintain or even improve muscle mass, strength, and function.[3,49] More recently, researchers reported that protein requirements may be higher in morbidly obese adults.[50]

This systematic review provides convincing evidence of the beneficial effects of resistance training. Other systematic reviews investigating healthy older persons with sarcopenia, but not obesity, underline the improvements shown in body fat and muscle function.[51,52] International guidelines also recommend the implementation of resistance-based exercise (and a protein-rich diet) to counteract sarcopenia.[53] However, evidence of the effectiveness of resistance training in achieving increased muscle mass is inconsistent.[51,52] The pathophysiological mechanisms that occur with higher age (eg, imbalance between anabolic and catabolic pathways that affect muscle protein) may make it very difficult to increase muscle mass in older age.[5] This is another argument for starting interventions at an earlier time point, such as the transition to retirement, to allow them to become part of everyday life.

The effectiveness of aerobic training is less clear, but there are indications that the combination of aerobic and resistance training in obese older individuals may be even more effective than resistance training alone.[54] For this review, only one study that investigated this issue in individuals with sarcopenic obesity around retirement age was identified.[30] Combined resistance and aerobic training was most effective for reducing body fat mass but not for improving muscle-specific outcomes. A combination of resistance training and aerobic exercise could be even more relevant for individuals with sarcopenic obesity than for persons with sarcopenia alone, since it aims at both body fat reduction and muscle gain/preservation. Experts and guidelines recommend a combination of moderate calorie restriction, increased protein intake, and exercise for the treatment of sarcopenic obesity.[16,44,49,53,55] The results of this systematic review, which is one of the first to focus on persons in a transitional phase of life (ie, retirement), confirm the effectiveness of resistance training on various outcomes. The effectiveness of nutritional interventions, however, remains uncertain.

This systematic review has some limitations. First, only a few of the included studies could be included in the statistical analysis. In particular, studies investigating nutritional interventions in individuals with sarcopenic obesity in retirement age were extremely heterogeneous, and thus data could not be pooled for these kind of interventions. Another noteworthy aspect is that 4 of the 7 included studies were conducted in Asian individuals. Asians differ in body composition from Caucasians. For example, they tend to have different body fat content and increased abdominal adiposity compared with Caucasians.[56] The generalizability of the results of the individual studies, therefore, is limited, and any application of the results to other ethnic groups should be done with caution. Second, the authors of the included studies used different definitions for both sarcopenia and obesity, which may have reduced the comparability of results. Third, even though a comprehensive search in several databases and trial registers was conducted, it is possible that some studies may have been overlooked.

CONCLUSION

The results of this systematic review suggest that resistance training in retirement age can be used to effectively treat sarcopenic obesity by reducing fat mass and increasing muscle mass, muscle strength, and gait speed. Adding higher protein intake to exercise may further increase the reduction in fat mass. Other interventions, such as aerobic training or specific dietary interventions, revealed significantly positive effects on some parameters of sarcopenic obesity in single studies, but the data could not be pooled. In general, data are scarce, and further intervention studies are urgently needed, especially those that investigate the effects of nutritional interventions in this target group. However, even while some questions remain open, retirement is a promising phase of life that should be used to adopt healthy habits (balanced diet and exercise) with the aim of maintaining the mobility and independence of aging persons for as long as possible. The prevention of weight gain, which is mostly a gain of fat mass, as well as the prevention of a decrease in muscle mass, strength, and function, should be prioritized in this phase of life.

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Supporting Information

The following Supporting Information is available through the online version of this article at the publisher's website.

Appendix S1 **Search strategies for the individual databases**

Table S1 **PRISMA checklist**

Table S2 **PRISMA 2020 checklist**

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