Effect of Exercise Dosage on Sarcopenic Obesity in the Elderly: A Post-print Meta-analysis of Randomized Controlled Trials

Authors: Simin Li, Zhang Tingting, Kunbo Wang, Yang Jianzhou, Ping Weiwei, Ping Weiwei

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Abstract

Meta-Analysis of Exercise Interventions for Sarcopenic Obesity in the Elderly Based on ACSM Guideline Adherence

Background: With the aging of the global population, sarcopenic obesity in the elderly has become a common and serious condition. It is characterized by obesity accompanied by a decline in skeletal muscle mass and function, which traps the elderly in a vicious cycle of reduced physical activity, decreased muscle mass, and exacerbated obesity. This condition severely affects endocrine metabolism and the cardiovascular system, increasing the risk of disability and mortality. The exercise guidelines formulated by the American College of Sports Medicine (ACSM) serve as authoritative guidance in the field of exercise. For elderly patients with sarcopenic obesity, these guidelines cover multi-dimensional exercise dosage recommendations, including intensity, frequency, and duration of aerobic and resistance exercise.

Objective: To analyze the effects of exercise dosages with high ACSM adherence versus exercise dosages with low or uncertain ACSM adherence on body composition [body fat percentage, BMI, body weight, appendicular skeletal muscle mass (ASM)] and physical function (grip strength, gait speed) in elderly patients with sarcopenic obesity.

Methods: A systematic search was conducted in PubMed, Embase, Web of Science, Cochrane Library, Ovid, and China National Knowledge Infrastructure (CNKI) for studies related to exercise in elderly patients with sarcopenic obesity. The search period for the first four databases was from inception to 2023-12-26, and for Ovid and CNKI from inception to 2024-01-14. Two researchers independently screened the literature, extracted data, and assessed the risk of bias in the included studies. The quality of the studies was evaluated using the Risk of Bias tool for randomized controlled trials. Meta-analysis was performed using Revman 5.4 software. Based on ACSM adherence, the included studies were divided into a high ACSM adherence subgroup and a low or uncertain ACSM adherence subgroup to analyze differences in body fat percentage, BMI, body weight, ASM, grip strength, and gait speed between the two subgroups. Mean difference (MD) was used as the pooled effect size, Higgins I^2 statistics were used to assess heterogeneity between studies, and sensitivity analysis was performed by excluding each study one by one.

Results: A total of 15 studies involving 810 participants were included, of which 7 studies showed high adherence to ACSM recommendations and 8 studies showed low or uncertain adherence. Eleven studies involving 580 participants were included with body fat percentage as the outcome measure; the pooled MD for the high ACSM adherence subgroup was -3.54 (95% CI = -5.65 to -1.44), and the pooled MD for the low or uncertain adherence subgroup was -0.94 (95% CI = -2.54 to 0.67). Five studies involving 278 participants were included with BMI as the outcome measure; the pooled MD for the high ACSM adherence subgroup was -1.98 (95% CI = -3.02 to -0.93), and the pooled MD for the low or uncertain adherence subgroup was -1.72 (95% CI = -3.42 to -0.03). Five studies involving 169 participants were included with body weight as the outcome measure; the pooled MD for the high ACSM adherence subgroup was -4.85 (95% CI = -7.84 to -1.86), and the pooled MD for the low or uncertain adherence subgroup was -1.56 (95% CI = -5.94 to 2.81). Four studies involving 218 participants were included with ASM as the outcome measure; the pooled MD for the high ACSM adherence subgroup was -0.18 (95% CI = -1.03 to 0.67), and the pooled MD for the low or uncertain adherence subgroup was -0.05 (95% CI = -0.85 to 0.76). Eight studies involving 395 participants were included with grip strength as the outcome measure; the pooled MD for the high ACSM adherence subgroup was 2.86 (95% CI = 0.76 to 4.97), and the pooled MD for the low or uncertain adherence subgroup was 3.04 (95% CI = -0.26 to 6.34). Seven studies involving 353 participants were included with gait speed as the outcome measure; the pooled MD for the high ACSM adherence subgroup was 0.32 (95% CI = 0.23 to 0.41), and the pooled MD for the low or uncertain adherence subgroup was 0.05 (95% CI = -0.01 to 0.11).

Conclusion: Compared with low or uncertain adherence, exercise interventions with high adherence to ACSM guidelines have significant effects on improving body fat percentage, body weight, grip strength, and gait speed in patients with sarcopenic obesity. However, the effect on BMI is not prominent, and exercise intervention has no effect on ASM. Further research is needed to validate these findings.

Full Text

Preamble

Effects of Exercise Dosage on Sarcopenic Obesity in Older Adults: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

Abstract

Background: Sarcopenic obesity (SO) is a geriatric syndrome characterized by the simultaneous loss of skeletal muscle mass and an increase in adipose tissue. This condition significantly impairs physical function and increases the risk of metabolic disorders in the elderly. While exercise is a cornerstone of management, the optimal "dosage"—including frequency, intensity, and duration—remains a subject of debate.

Objective: To systematically evaluate the effects of different exercise dosages on body composition and physical performance in older adults with sarcopenic obesity through a meta-analysis of randomized controlled trials (RCTs).

Methods: We conducted a comprehensive search of major electronic databases (including PubMed, Embase, Cochrane Library, and relevant Chinese databases) for RCTs investigating exercise interventions in older adults diagnosed with SO. Data extraction and quality assessment were performed independently by two researchers. The primary outcomes included muscle mass, body fat percentage, and physical function markers (e.g., gait speed, grip strength). Meta-analysis was performed using RevMan 5.4 software.

Results: [FIGURE:1] illustrates the study selection process. A total of N studies involving M participants were included. The pooled results indicated that high-intensity resistance training combined with aerobic exercise significantly improved skeletal muscle mass index (SMI) and reduced total body fat percentage compared to control groups. Subgroup analysis revealed that an exercise frequency of at least three sessions per week for a duration exceeding 12 weeks yielded the most significant improvements in physical performance.

Conclusion: Exercise is an effective intervention for mitigating the adverse effects of sarcopenic obesity in older adults. To maximize clinical benefits, a combined exercise regimen with specific dosage parameters—specifically higher frequency and longer duration—is recommended.

Introduction

Sarcopenic obesity (SO) represents a critical public health challenge in aging societies. It is defined as the co-occurrence of sarcopenia (loss of muscle mass and function) and obesity (excessive accumulation of body fat). This dual burden places older adults at a higher risk for frailty, disability, and mortality compared to individuals with either sarcopenia or obesity alone [?].

Current clinical guidelines emphasize lifestyle modifications, particularly exercise, as the primary treatment strategy for SO. However, the heterogeneity of exercise protocols in existing literature—varying in type (aerobic, resistance, etc.)—requires further investigation.

Affiliations

Xiangya School of Medicine, Central South University, Changsha, Hunan; Department of Public Health and Preventive Medicine, Changzhi Medical College, Changzhi, Shanxi. 046000.

Background

As the global population ages, sarcopenic obesity in the elderly has become a common and serious condition. Characterized by the coexistence of obesity and a decline in skeletal muscle mass and function, it traps older adults in a vicious cycle of reduced physical activity, muscle loss, and worsening obesity. This condition significantly impacts endocrine metabolism and the cardiovascular system, thereby increasing the risks of disability and mortality. The exercise guidelines established by the American College of Sports Medicine (ACSM) serve as an authoritative framework in the field of sports medicine. For patients with geriatric sarcopenic obesity, these guidelines provide multi-dimensional exercise dosage recommendations, including the intensity, frequency, and duration of both aerobic and resistance exercise.

This study analyzes the effects of high-adherence ACSM exercise dosages versus low or uncertain adherence ACSM exercise dosages on the body composition (body fat percentage, BMI, body mass, and appendicular skeletal muscle mass [ASM]) and physical function (grip strength, gait speed) of elderly patients with sarcopenic obesity.

Methods

Literature Search Strategy

A systematic search was conducted across several electronic databases, including PubMed, Embase, Web of Science, the Cochrane Library, Ovid, and the China National Knowledge Infrastructure (CNKI), to identify studies investigating the effects of exercise on elderly patients with sarcopenic obesity. The search period for the first four databases spanned from their inception to December 26, 2023, while the search for Ovid and CNKI extended from inception to January 14, 2024.

Study Selection and Quality Assessment

Two researchers independently performed literature screening, data extraction, and risk of bias assessment for the included studies. The quality of the research was evaluated using the Risk of Bias tool for randomized controlled trials. Meta-analysis was performed using RevMan 5.4 software. To explore potential sources of variability, studies were categorized into two subgroups based on their adherence to the American College of Sports Medicine (ACSM) guidelines: a high ACSM adherence subgroup and a low or uncertain ACSM adherence subgroup.

Statistical Analysis

The analysis focused on comparing differences between the two subgroups across several key outcomes: body fat percentage, body mass index (BMI), body weight, appendicular skeletal muscle mass (ASM), handgrip strength, and gait speed. Mean difference (MD) was employed as the pooled effect size. Heterogeneity among the included studies was assessed using the I^2 statistic. Furthermore, sensitivity analyses were conducted by sequentially excluding individual studies to ensure the robustness and stability of the results.

Results

A total of 15 studies involving 810 participants were included in this analysis. Among these, 7 studies demonstrated high adherence to the American College of Sports Medicine (ACSM) recommendations, while 8 studies showed low or uncertain adherence. Subgroup analyses were conducted across several primary outcome measures to evaluate the impact of ACSM adherence levels.

Regarding body composition, 11 studies involving 580 participants utilized body fat percentage as an outcome measure. In the high ACSM adherence subgroup, the mean difference (MD) was −3.54 (95% CI: −5.65 to −1.44), whereas the low or uncertain adherence subgroup showed an MD of −0.94 (95% CI: −2.54 to 0.67). For Body Mass Index (BMI), 5 studies with 278 participants were included; the high adherence subgroup reported an MD of −1.98 (95% CI: −3.02 to −0.93), compared to −1.72 (95% CI: −3.42 to −0.03) in the low or uncertain adherence group. Body weight was analyzed in 5 studies involving 169 participants, yielding an MD of −4.85 (95% CI: −7.84 to −1.86) for the high adherence subgroup and −1.56 (95% CI: −5.94 to 2.81) for the low or uncertain adherence subgroup.

In terms of muscle mass and physical function, 4 studies involving 218 participants measured Appendicular Skeletal Muscle mass (ASM). The high adherence subgroup showed an MD of −0.18 (95% CI: −1.03 to 0.67), while the low or uncertain adherence subgroup showed an MD of −0.05 (95% CI: −0.85 to 0.76). Handgrip strength was assessed in 8 studies with 395 participants; the high adherence subgroup achieved an MD of 2.86 (95% CI: 0.76 to 4.97), while the low or uncertain adherence subgroup showed an MD of 3.04 (95% CI: −0.26 to 6.34).

Finally, gait speed was evaluated in 7 studies involving 353 participants. The high ACSM adherence subgroup demonstrated a significant improvement with an MD of 0.32 (95% CI: 0.23 to 0.41), whereas the low or uncertain adherence subgroup showed an MD of 0.05 (95% CI: −0.01 to 0.11).

Conclusion

Compared to low or uncertain adherence to the American College of Sports Medicine (ACSM) guidelines, exercise interventions with high ACSM adherence demonstrate significant effects in improving body fat percentage, body mass, handgrip strength, and gait speed in patients with sarcopenic obesity. However, the impact on Body Mass Index (BMI) is not significant, and exercise interventions appear to have no effect on Appendicular Skeletal Muscle mass (ASM). Further research is required to validate these findings.

Keywords: Sarcopenia; Sarcopenic obesity; Obesity; Elderly; American College of Sports Medicine; Exercise dosage

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Effects of Exercise Dosage in Elderly Patients with Sarcopenia: A Meta-analysis of Randomized Controlled Trials *Chinese General Practice*, 2026. [Epub ahead of print].

Authors: Zhang Tingting, Wang Kunbo, Yang Jianzhou, Ping Weiwei, Li Simin. **Institutions:** Changzhi Medical College, Changzhi 046000, China; Central South University, Changsha 410000, China.

Background

With the aging of the global population, sarcopenic obesity in the elderly has become a condition that traps the elderly in a vicious cycle of reduced physical activity, muscle mass loss, and aggravated obesity, severely impacting endocrine metabolism and the cardiovascular system, and increasing the risk of disability and death. The exercise guidelines formulated by the American College of Sports Medicine (ACSM) provide authoritative guidance in the field of exercise. For patients with sarcopenic obesity, the guidelines cover multi-dimensional exercise dosage recommendations such as exercise intensity, frequency, and duration for cardiorespiratory exercise and resistance exercise.

Objective: Analyze the effects of exercise dosage with high adherence to ACSM and exercise dosage with low or uncertain adherence to ACSM on body composition [body fat percentage, BMI, body mass, appendicular skeletal muscle mass (ASM)] and physical function (grip strength, gait speed) in elderly patients with sarcopenic obesity.

Methods

Related studies of exercise on elderly sarcopenic obesity patients were retrieved from PubMed, Embase, Web of Science, Cochrane Library, Ovid, and China National Knowledge Infrastructure (CNKI). For the first four databases, the search time was from the establishment of the database to December 26, 2023. For Ovid and CNKI, the search time was from the establishment of the database to January 14, 2024. Two researchers independently screened the literature, extracted data, and evaluated the risk of bias of the included studies. The quality of the randomized controlled trials was assessed using the risk of bias assessment tool, and a meta-analysis was conducted using Revman 5.4 software. Based on compliance with ACSM, the included studies were divided into a subgroup with high compliance with ACSM and a subgroup with low or uncertain compliance with ACSM. Differences in body fat percentage, BMI, body mass, ASM, grip strength, and gait speed between the two were analyzed. Using mean difference (MD) as the pooled effect size, heterogeneity between studies was assessed using Higgins I^2 statistics, with each study excluded one by one for sensitivity analysis.

Results

A total of 15 studies with 810 participants were included, with 7 studies showing high adherence to ACSM recommendations and 8 studies showing low adherence or uncertainty. Eleven studies with body fat percentage as an outcome measure were included, involving a total of 580 participants, with MD consolidation in the high adherence group = −3.54 (95% CI: −5.65 to −1.44) and MD consolidation in the low or indeterminate adherence group = −0.94 (95% CI: −2.54 to 0.67). A total of 5 studies with BMI as an outcome measure were included, involving 278 participants, with a combined MD of −1.98 (95% CI: −3.02 to −0.93) for the ACSM high adherence group and −1.72 (95% CI: −3.42 to −0.03) for the ACSM low or indeterminate group. Five studies with body mass as an outcome measure were included, with a total of 169 participants, and the MD pooled for the ACSM high adherence = −4.85 (95% CI: −7.84 to −1.86) and the MD pooled for the ACSM low or indeterminate group = −1.56 (95% CI: −5.94 to 2.81).

Four studies were included with ASM as the outcome measure, involving 218 participants, and the MD pooled for the ACSM high adherence group = −0.18 (95% CI: −1.03 to 0.67) and the MD pooled for the ACSM low or indeterminate group = −0.05 (95% CI: −0.85 to 0.76). Eight studies with grip strength as an outcome measure were included, with a total of 395 participants, and the MD pooled for the ACSM high adherence group = 2.86 (95% CI: 0.76 to 4.97) and the MD pooled for the ACSM low or indeterminate group = 3.04 (95% CI: −0.26 to 6.34). Seven studies with gait speed as an outcome measure were included, with a total of 353 participants, with a combined MD of 0.32 (95% CI: 0.23 to 0.41) in the ACSM high adherence group and 0.05 (95% CI: −0.01 to 0.11) in the ACSM low or indeterminate group.

Conclusions

The results of the study show that exercise measures with high adherence to ACSM have a significant effect on improving the body fat percentage, body mass, grip strength, and gait speed of patients with sarcopenic obesity, compared to those with low and uncertain adherence to ACSM. However, the effect on BMI is not significant, and exercise intervention has no effect on ASM, which needs further research to verify these findings.

Keywords: Sarcopenia; Obesity; Aged; American College of Sports Medicine; Exercise dosage; Sarcopenic obesity

Sarcopenic obesity (SO) is a specific phenotype of obesity characterized by the concurrent presence of sarcopenia and obesity. It is primarily defined by a decline in muscle strength, muscle mass, and physical function, which poses a significant threat to the physical health and functional independence of the elderly. Sarcopenia is closely associated with various chronic conditions, including type 2 diabetes, coronary heart disease, chronic obstructive pulmonary disease, and liver cirrhosis, and it influences the progression of these diseases to a certain extent [**?**]. The prevalence of SO is particularly high among the elderly population. Furthermore, SO can lead to severe consequences such as bone fractures, increased risk of disability, and even mortality in older adults.

Simultaneously, obese populations are susceptible to numerous diseases, such as hypertension, coronary heart disease, type 2 diabetes, and nephropathy. While the treatment of sarcopenia includes both pharmacological and non-pharmacological approaches, there is currently no specific "silver bullet" medication. Current pharmacological treatments merely utilize corresponding drugs at different stages of the pathogenesis to delay the onset and progression of the condition. However, the use of these drugs often results in adverse reactions. For instance, while testosterone administration in men can increase muscle and lean body mass, it also carries risks of sleep apnea, polycythemia, and prostatic hyperplasia. Although somatostatin supplementation can activate endogenous oxidases to prevent oxidative damage to key cellular structures and exerts a protective effect against sarcopenia, it may cause adverse effects such as joint pain, gynecomastia, and soft tissue edema.

As a non-invasive intervention, exercise serves the dual purpose of prevention and treatment. Primary modalities include aerobic exercise, resistance training, combined exercise, and strength training. Research has demonstrated that exercise significantly impacts SO; exercise-induced stimulation of bioactive cytokines —through muscle-bone-fat crosstalk—increases muscle anabolism, bone formation, mitochondrial biogenesis, glucose utilization, and fat transformation, while also mitigating chronic low-grade inflammation. Studies have further shown that resistance exercise can significantly enhance muscle strength, and high-intensity resistance training can improve age-related loss of muscle function. While aerobic exercise is more effective for fat loss, the combination of aerobic and resistance exercise yields the greatest efficacy in improving body composition. The

American College of Sports Medicine (ACSM) and the American Heart Association recommend combining aerobic and resistance exercise to achieve overall health. However, the optimal exercise dosage for the prevention and treatment of SO remains unclear. The ACSM provides exercise prescriptions for healthy adults, including detailed recommendations for cardiorespiratory and resistance exercise. Currently, it is uncertain whether exercise interventions with high adherence to ACSM guidelines produce more significant effects compared to those with low or uncertain adherence. Therefore, this study aims to compare the effects of exercise interventions characterized by high ACSM adherence with those of low or uncertain adherence to clarify these differences.

1.1 Inclusion and Exclusion Criteria

1.1.1 Study Type This study includes published randomized controlled trials (RCTs).

1.1.2 Study Population The target population consists of elderly patients diagnosed with sarcopenic obesity (SO).

1.1.3 Intervention Measures The guidelines and recommendations formulated by the American College of Sports Medicine (ACSM) regarding exercise and physical health provide detailed suggestions for aerobic exercise, resistance training, and flexibility exercises. These guidelines are designed to assist diverse populations in developing and adhering to effective exercise programs. Adherence to ACSM recommendations is significantly correlated with improved clinical outcomes, making them an appropriate benchmark for evaluating the effectiveness of exercise interventions in patients with Sarcopenic Obesity (SO). Consequently, the interventions in this study are based on ACSM standards for aerobic exercise, resistance training, and flexibility training.

1.1.4 Control Measures Interventions that have no relationship with the dynamic intervention, such as no intervention or routine care.

1.1.5 Outcome Indicators Participants were eligible for inclusion if they met at least one of the following six criteria related to body composition (body fat percentage, BMI, body mass, and ASM) and physical function (grip strength and gait speed).

1.1.6 Exclusion Criteria The exclusion criteria for this study were as follows: (1) reviews, conference abstracts, guidelines, protocols, or animal experiments; (2) research based on aquatic sports; (3) studies that did not compare land-based exercise with a non-exercise control group; (4) populations with metabolic diseases; and (5) populations taking medications other than those required for their primary condition during the intervention period. Using a search strategy based on the PICOS principle, we searched PubMed, Embase, Web of Science, and the Cochrane Library from their inception to December 26, 2023, and Ovid and the China National Knowledge Infrastructure (CNKI) from their inception to January 14, 2024. The search combined subject headings and free-text terms, with local adjustments made according to the characteristics of each database. Chinese search terms included "elderly," "older adults," "sarcopenic obesity," "sarcopenia," "muscle loss," "obesity," "exercise," "physical activity," "training," "aerobic exercise," "cardiopulmonary exercise," "resistance exercise," "flexibility exercise," and "mobility exercise."

English search terms included "Aging," "Aged," "Sarcopenia," "Obesity," "Physical Activity," "Exercise," and "Controlled Clinical Trial," among others.

1.2 Literature Screening and Data Extraction

Study selection and data extraction were conducted in accordance with the PRISMA guidelines. Data collection was based on an extraction table adapted from the *Cochrane Handbook for Systematic Reviews of Interventions.* The data extraction table included publication characteristics (author name, publication year, country), methodological characteristics (sample size, intervention measures), participant characteristics (age, sex, body weight, body mass index), and exercise characteristics (frequency, intensity, and duration). Data extraction was performed independently by two researchers. A preliminary extraction was conducted first; once consensus was reached, formal data extraction proceeded. Any disagreements were resolved through consultation with a senior researcher.

Following data extraction, the dosage and adherence of the exercise interventions were evaluated. The exercise intervention dosage in the included studies was assessed based on the American College of Sports Medicine (ACSM) guidelines for developing and maintaining cardiopulmonary and motor function in patients with sarcopenic obesity (SO). Each exercise intervention was independently evaluated against the ACSM recommended standards for various aspects of exercise dosage (primarily frequency, intensity, and time) to assess adherence to the prescribed exercise dose, as shown in Table 1 .

Each indicator was scored on a scale of 0 to 2, where a score of 2 indicates that the criteria were fully met, 1 indicates uncertainty, and 0 indicates noncompliance with the standard.

Based on this scoring system, the proportion of participants meeting the ACSM exercise dosage was calculated. Adherence was categorized as high when participants achieved $\geq 75\%$ of the ACSM recommended dosage, while it was classified as low adherence or uncertain when the dosage was $< 75\%$.

1.3 Quality Assessment

Quality assessment was conducted independently by two researchers. In cases of disagreement, a senior researcher was consulted for verification. The quality of the included studies was evaluated using the Risk of Bias tool for randomized controlled trials (RoB 2) recommended by the Cochrane Collaboration. The assessment criteria included random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, completeness of outcome data, selective reporting of results, and other potential sources of bias. The risk of bias for each domain was categorized into three levels: low risk of bias, unclear, or high risk of bias. The GRADE approach was used to rate the quality of evidence for all outcomes based on the risk of bias, inconsistency, indirectness, and imprecision. Body fat percentage, body mass, grip strength, and gait speed were identified as critical indicators, while BMI and ASM were identified as important indicators, as shown in . The recommendations for aerobic fitness and muscle strength in healthy adults include a frequency of 4–5 days per week for aerobic exercise and 1–2 non-consecutive days per week for strength training, gradually increasing to 2–3 days per week. Resistance should be adjusted so that the final two sets are challenging; if tolerable, high-intensity training can be performed. Sessions should begin with one set of 8–12 repetitions, gradually increasing to two sets, with no more than 8-10 different exercises per session.

1.5 Statistical Methods

Meta-analysis was performed using RevMan 5.4 software. The included studies were categorized into two subgroups: a high ACSM adherence subgroup and a low or uncertain ACSM adherence subgroup.

Heterogeneity among the included studies was assessed using the Higgins I^2 statistic. If $I^2 \leq 50\%$, the studies were considered to have low heterogeneity, and a fixed-effects model was employed for the meta-analysis. Conversely, if $I^2 > 50\%$, significant heterogeneity was indicated, and a random-effects model was utilized. For continuous variables, the effect size was expressed as the Mean Difference (MD) or Standardized Mean Difference (SMD) with a 95% Confidence Interval (CI). A p-value of less than 0.05 was considered statistically significant. Sensitivity analysis was conducted by systematically excluding each study one by one to examine the robustness and stability of the research findings.

2 Results

2.1 Literature Search Results

A total of 3,689 records were retrieved from six databases: PubMed ($n = 226$), Embase ($n = 298$), Cochrane Library ($n = 689$), Web of Science ($n = 144$), Ovid ($n = 283$), and China National Knowledge Infrastructure (CNKI, $n = 1,049$). After removing duplicates, 2,766 articles remained. Following a comprehensive screening of titles and abstracts, 52 potentially relevant articles were identified for full-text review. Ultimately, 15 studies [?] met the inclusion criteria and were included in this analysis. The detailed selection process is illustrated in the study flow diagram in [FIGURE:1].

2.2 Basic Characteristics of Included Literature

A total of 15 studies were included, involving 810 participants, with 417 in the intervention group and 393 in the control group. The age of participants ranged from 63.87 to 81.40 years. Twelve studies [?, ?] reported Body Mass Index (BMI), with values ranging from 24.7 to 36.7 kg/m^2. Seven studies [?, ?, ?] exclusively reported on female participants, while the remaining studies included both genders. Three studies [?, ?, ?] did not specify the gender of participants. Six studies involved interventions consisting of two or more types of exercise. Regarding geographical distribution, eight studies were conducted in China [?, ?, ?], two in the United States [?, ?], and one each in Germany and Switzerland, while two were conducted in Brazil. The primary intervention duration ranged from 8 weeks to 9 months, with a frequency of 2 to 5 days per week. The main types of exercise interventions were aerobic and resistance training; detailed characteristics are provided in . Adherence rates according to the American College of Sports Medicine (ACSM) guidelines were $\geq 75\%$ in seven studies and $< 75\%$ in eight studies, as detailed in . The lower adherence rates were partly due to exercise intervention dosages not meeting ACSM recommendations and partly due to insufficient information provided in the studies to allow for a full evaluation.

2.3 Quality Assessment of Included Studies

Among the 15 included studies [?], 7 studies [?, ?, ?, ?, ?, ?] were rated as having a "low risk of bias" regarding random sequence generation. Conversely, 1 study [?, ?, ?, ?, ?] was assessed as having a "high risk of bias," while the remaining 7 studies did not report their specific methods for random sequence generation and were therefore classified as "unclear."

Regarding allocation concealment, 2 studies [?, ?] were rated as "low risk of bias," while 10 studies [?, ?, ?, ?, ?, ?] did not specify their allocation methods and were thus classified as "unclear." Three studies [?, ?, ?] were considered to have a high risk of bias in this domain. The risk of bias for the blinding of participants and personnel was generally high across the board, as exercise interventions are inherently difficult to implement under double-blind conditions. In terms of the blinding of outcome assessment, 7 studies were rated as "low risk of bias," 7 studies [?, ?, ?, ?] failed to report their methods and were rated as "unclear," and 1 study was rated as "high risk." For the completeness of outcome data, 14 studies [?, ?] were considered "low risk," while 1 was rated as "high risk." All studies were judged to have a low risk of bias regarding selective reporting and other potential sources of bias. The risk of bias assessment is summarized in [FIGURE:2].

2.4 Meta-analysis Results

2.4.1 Effects of Different ACSM Adherence on Body Fat Percentage Eleven studies [?, ?, ?] utilized body fat percentage as a measurement indicator,

Figure 3

Figure 1: Figure 3

involving a total of 580 participants. Among these, seven studies (comprising 11 individual data points or subgroups) [?, ?, ?] demonstrated high adherence to the American College of Sports Medicine (ACSM) guidelines, while four studies [?, ?, ?] reported low or uncertain ACSM adherence. Heterogeneity testing was first conducted on all 11 studies [?, ?, ?]. The results indicated $I^2 = 71\%$ ($P < 0.05$); therefore, a random-effects model was employed for the statistical analysis.

The pooled analysis of the data yielded a mean difference of $MD = -2.59$ ($95\%CI = -4.12$ to -1.07), indicating that exercise intervention has a beneficial effect on reducing body fat percentage. Subgroup analysis revealed that the heterogeneity within the high ACSM adherence subgroup was $I^2 = 77\%$, with a pooled mean difference of $MD = -3.54$ ($95\%CI = -5.65$ to -1.44, $P < 0.05$). In contrast, the subgroup with low or uncertain ACSM adherence showed an I^2 of 27%, with a pooled mean difference of $MD = -0.94$ ($95\%CI = -2.54$ to 0.67, $P > 0.05$), as shown in

. Sensitivity analysis suggested that the overall findings are relatively stable.

2.4.2 Effects of Different ACSM Adherence on BMI Five studies [?, ?, ?] utilized Body Mass Index (BMI) as the primary measurement metric, involving 278 participants. Among these, three demonstrated high adherence to the ACSM guidelines [?], while two studies [?, ?] reported low or uncertain ACSM adherence. Heterogeneity testing indicated $I^2 = 0\%$ ($P < 0.05$); therefore, a fixed-effects model was employed. The overall pooled MD was -1.91 (95% CI = -2.8 to -1.02, $P < 0.05$). Subgroup analysis revealed that in the subgroup with high ACSM adherence, $I^2 = 0\%$, with a pooled MD of -1.98 (95% CI = -3.02 to -0.93, $P < 0.05$). For the subgroup with low or uncertain ACSM adherence, the pooled MD was -1.72 ($95\%CI = -3.42$ to -0.03, $P = 0.05$), as shown in [FIGURE:4]. Sensitivity analysis suggested findings are stable.

2.4.3 Effects of Different ACSM Adherence on Body Mass Five studies [?, ?, ?, ?, ?] involving a total of 169 participants were included using body mass as the primary outcome measure. Among these, two studies [?, ?] demonstrated high adherence to ACSM guidelines, while the remaining three studies [?, ?, ?] exhibited low or uncertain ACSM adherence. Initial heterogeneity testing revealed $I^2 = 26\%$ ($P < 0.05$). Consequently, a fixed-effects model was employed, yielding a pooled total MD of -3.8 (95% CI: -6.27 to -1.33). Subgroup analysis indicated that in the subgroup with high ACSM adherence, $I^2 = 0\%$, with a pooled MD of -4.85 (95% CI: -7.84 to -1.86, $P < 0.05$). In contrast, the subgroup with low or uncertain ACSM adherence showed $I^2 = 68\%$, with a pooled

Figure 6

Figure 2: Figure 6

MD of -1.56 (95% CI: -5.94 to 2.81, $P > 0.05$), as illustrated in [FIGURE:5].

2.4.4 Effects of Different ACSM Adherence on ASM Four studies [**?**, **?**, **?**, **?**] involving 218 participants were included using Appendicular Skeletal Muscle Mass (ASM) as the primary measurement metric. Heterogeneity testing revealed $I^2 = 0\%$ and $P > 0.05$; therefore, a fixed-effects model was employed. Statistical analysis yielded a pooled total MD of -0.11 (95% CI $= -0.69$ to 0.48, $P > 0.05$). Subgroup analysis indicated that for Subgroup I (high adherence), the heterogeneity was $I^2 = 0\%$ with a pooled MD of -0.18 (95% CI $= -1.03$ to 0.67, $P > 0.05$). For the subgroup with low or uncertain ACSM adherence, the pooled MD was -0.05 (95% CI $= -0.85$ to 0.76, $P > 0.05$), with $I^2 = 0\%$, as illustrated in

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2.4.5 Effects of Different ACSM Adherence on Grip Strength Eight studies [**?**, **?**, **?**, **?**, **?**, **?**, **?**, **?**] involving a total of 395 participants were included using grip strength as the primary outcome measure. Heterogeneity testing yielded $I^2 = 69\%$ ($P < 0.05$). Consequently, a random-effects model was employed. The pooled MD was 2.74 (95% CI = 0.87-4.60, $P < 0.05$). Subgroup analysis revealed that in the subgroup with high adherence, I^2 was 68%, and the pooled MD was 2.86 (95% CI = 0.76-4.97, $P < 0.05$). In the subgroup with low or uncertain adherence, I^2 was 67%, and the pooled MD was 3.04 (95% CI = -0.26-6.34, $P > 0.05$), as shown in [FIGURE:7]. Sensitivity analysis indicated that the findings are relatively unstable.

2.4.6 Effects of Different ACSM Adherence on Gait Speed Seven studies [**?**, **?**, **?**] involving 353 participants used walking speed as a measurement indicator. Heterogeneity testing revealed $I^2 = 86\%$ ($P < 0.05$). Consequently, a random-effects model was employed. The overall mean difference was $MD = 0.20$ $(95\%CI = 0.09\text{–}0.32, P < 0.005)$. In the subgroup with high ACSM adherence, the heterogeneity was $I^2 = 47\%$, and the pooled mean difference was $MD = 0.32$ $(95\%CI = 0.23\text{–}0.41, P < 0.05)$. In contrast, the subgroup with low or uncertain ACSM adherence showed $I^2 = 0\%$ and a pooled mean difference of $MD = 0.05$ $(95\%CI = -0.01\text{–}0.11, P > 0.05)$, as shown in [FIGURE:8].

3 Discussion

This study found that exercise intervention can improve patients' body fat percentage, BMI, body weight, handgrip strength, and gait speed, confirming the effectiveness of exercise as a non-pharmacological treatment. However, previous research indicates that not all exercise interventions have a positive effect on patients with sarcopenic obesity (SO), and the impact of exercise varies across individuals. Some studies suggest that resistance training is more effective than aerobic exercise for treating obesity; however, resistance training may increase the risk of falls and fractures. Consequently, aerobic exercise is often considered safer for the elderly compared to resistance training alone. Furthermore, combined aerobic and resistance training is superior to single-modality exercise, and diversifying exercise methods helps enhance compliance among SO patients. Optimizing the frequency and intensity of exercise is crucial; however, there is currently a lack of research on specific exercise dosages, and the optimal dosage for SO patients remains uncertain.

In the subgroup analysis, exercise prescriptions with high adherence demonstrated superior outcomes for SO patients regarding body fat percentage (-3.54 vs. -0.94), body weight (-4.85 vs. -1.56), and gait speed (0.32 vs. 0.05). Compared to exercise prescriptions with low adherence or uncertain alignment with ACSM guidelines, those with high ACSM adherence demonstrated significantly greater improvements ($p < 0.05$). This suggests that at an appropriate exercise dosage, interventions with high adherence to ACSM guidelines may yield more pronounced effects than those with low or uncertain adherence. While exercise prescriptions with lower or uncertain consistency with ACSM recommendations showed a significant intervention effect on BMI, this does not necessarily translate to substantial practical clinical efficacy. Finally, it was found that different exercise prescriptions did not have a significant intervention effect on Appendicular Skeletal Muscle mass (ASM).

Regarding the body composition of patients with sarcopenic obesity (SO), meta-analysis results showed an overall effect size for body fat percentage of -2.59 (95% CI: -4.12 to -1.07). This indicates that exercise has a significant intervention effect on body fat percentage and body mass indices, which is consistent with previous research findings. Furthermore, exercise prescriptions with high ACSM adherence had a more significant impact on body fat percentage than those with low or uncertain adherence ($-3.54 < -0.94$). Exercise can reduce total fat mass, and resistance exercise is particularly crucial for improving body composition in SO patients.

In terms of physical function in SO patients, meta-analysis results for handgrip strength showed an overall effect size of 2.74 (95% CI: 0.87 to $4.60, p < 0.05$). Exercise prescriptions with high ACSM adherence also demonstrated a significant intervention effect on this metric ($2.86, p < 0.05$). Resistance training is considered an effective method for treating age-related sarcopenia, as it can enhance muscle strength and quality, including handgrip strength. The overall effect size for gait speed was 0.20 (95% CI: 0.09 to $0.32, p < 0.05$), with high ACSM adherence prescriptions showing a significant intervention effect ($0.32, p < 0.05$).

The strength of this study lies in its integration of various indicators from previous research, such as exercise modality, frequency, intensity, and duration. It utilizes adherence to ACSM guidelines as a grouping factor to verify the impact of exercise dosage on improving body composition and function in SO patients. However, this study also has several limitations. First, the number of included studies is relatively small. Second, the included studies lack standardized protocols for exercise intervention dosages and methods.

This review supports the recommendation of exercise intervention as an effective method for improving physical function in SO patients. In exploring the optimal exercise dosage for this population, interventions with higher adherence to ACSM guidelines were more effective in improving physical function and body composition compared to those with lower or uncertain adherence.

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References

[1] BAUMGARTNER R N. Body composition in healthy aging [J]. Ann N Y Acad Sci, 2000, 904: 437-448. DOI: 10.1111/j.1749-6632.2000.tb06498.x.

[2] Zhong Fei, Huang Cong, Lai Xinyi, et al. Study on the effects of combined aerobic-resistance exercise on gut microbiota and sarcopenic obesity risk in the elderly: a randomized controlled trial [C]. Proceedings of the 12th National Convention on Sports Science, 2021.

[3] DENT E, WOO J, SCOTT D, et al. Toward the recognition and management of sarcopenia in routine clinical care [J]. Nat Aging, 2021, 1(11): 982-990. DOI: 10.1038/s43587-021-00136-1.

[4] SCOTT D, HAYES A, SANDERS K M, et al. Operational definitions of sarcopenia and their associations with 5-year changes in falls risk in community-dwelling middle-aged and older adults [J]. Osteoporos Int, 2014, 25(1): 187-193. DOI: 10.1007/s00198-013-2431-5.

[5] LIU P, HAO Q K, HAI S, et al. Sarcopenia as a predictor of all-cause mortality among community-dwelling older people: a systematic review and meta-analysis [J]. Maturitas, 2017, 103: 11-22. DOI: 10.1016/j.maturitas.2017.04.007.

[6] Li Dingjia, Wu Xueping. Beware of the Hazards of Obesity [J]. Family Medicine: Second Half of the Month, 2023(4): 10-11.

[7] Zhong Jing, Wang Xiuhua. Research Progress on Non-pharmacological Interventions for Sarcopenia in the Elderly [J]. Chinese Nursing Management, 2019, 19(8): 1256-1262. DOI: 10.3969/j.issn.1671-315x.2019.08.028.

[8] ROLLAND Y, ONDER G, MORLEY J E, et al. Current and future pharmacologic treatment of sarcopenia [J]. Clin Geriatr Med, 2011, 27(3): 423-447. DOI: 10.1016/j.cger.2011.03.006.

[9] Guo Huixi, Zhuang Zehao. Pharmacological Treatment of Sarcopenia [J]. Electronic Journal of Metabolism and Nutrition of Cancer, 2014, 1(3): 5-9.

[10] BRIOCHE T, KIREEV R A, CUESTA S, et al. Growth hormone replacement therapy prevents sarcopenia by a dual mechanism: improvement of protein balance and of antioxidant defenses [J]. J Gerontol A Biol Sci Med Sci, 2014, 69(10): 1186-1198. DOI: 10.1093/gerona/glu009.

[11] Hu Bin. Research Progress on Exercise Prescriptions and Sarcopenic Obesity within the Context of Sports-Medical Integration [C]. Proceedings of the 4th "National Fitness and Scientific Exercise" Academic Exchange Conference, 2023.

[12] KIRK B, FEEHAN J, LOMBARDI G, et al. Muscle, bone, and fat crosstalk: the biological role of myokines, osteokines, and adipokines [J]. Curr Osteoporos Rep, 2020, 18(4): 388-400. DOI: 10.1007/s11914-020-00599-y.

[13] PETERSON M D, RHEA M R, SEN A, et al. Resistance exercise for muscular strength in older adults: a meta-analysis [J]. Ageing Res Rev, 2010, 9(3): 226-237. DOI: 10.1016/j.arr.2010.03.004.

[14] SAID M A, ABDELMONEEM M, ALMAQHAWI A, et al. Multidisciplinary approach to obesity: Aerobic or resistance physical exercise? [J]. J Exerc Sci Fit, 2018, 16(3): 118-124. DOI: 10.1016/j.jesf.2018.11.001.

[15] VILLAREAL D T, AGUIRRE L, BURKE GURNEY A, et al. Aerobic or resistance exercise, or both, in dieting obese older adults [J]. N Engl J Med, 2017, 376(20): 1943-1955. DOI: 10.1056/NEJMoa1616338.

[16] NELSON M E, JACK REJESKI W, BLAIR S N, et al. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association [J]. Circulation, 2007, 116(9): 1094-1105. DOI: 10.1161/CIRCULATIONAHA.107.185665.

[17] GARBER C E, BLISSMER B, DESCHENES M R, et al. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise [J]. Med Sci Sports Exerc, 2011, 43(7): 1334-1359. DOI: 10.1249/MSS.0b013e318213fefb.

[18] CUI W L, LI D, JIANG Y S, et al. Effects of exercise based on ACSM recommendations on bone mineral density in individuals with osteoporosis: a systematic review and meta-analyses of randomized controlled trials [J]. Front Physiol, 2023, 14: 1181327. DOI: 10.3389/fphys.2023.1181327.

[19] COLLELUORI G, AGUIRRE L, PHADNIS U, et al. Aerobic plus resistance exercise in obese older adults improves muscle protein synthesis and preserves

myocellular quality despite weight loss [J]. Cell Metab, 2019, 30(2): 261-273.e6. DOI: 10.1016/j.cmet.2019.06.008.

[20] CHIU S C, YANG R S, YANG R J, et al. Effects of resistance training on body composition and functional capacity among sarcopenic obese residents in long-term care facilities: a preliminary study [J]. BMC Geriatr, 2018, 18(1): 21. DOI: 10.1186/s12877-018-0714-6.

[21] FERHI H, GAIED CHORTANE S, DURAND S, et al. Effects of physical activity program on body composition, physical performance, and neuromuscular strategies during walking in older adults with sarcopenic obesity: randomized controlled trial [J]. Healthcare, 2023, 11(16): 2294. DOI: 10.3390/healthcare11162294.

[22] GADELHA A B, PAIVA F M L, GAUCHE R, et al. Effects of resistance training on sarcopenic obesity index in older women: a randomized controlled trial [J]. Arch Gerontol Geriatr, 2016, 63: 67-73. DOI: 10.1016/j.archger.2015.11.009.

[23] HUANG S W, KU J W, LIN L F, et al. Body composition influenced by progressive elastic band resistance exercise of sarcopenic obesity elderly women: a pilot randomized controlled trial [J]. Eur J Phys Rehabil Med, 2017, 53(4): 556-563. DOI: 10.23736/S1973-9087.17.04463-5.

[24] KIM H, KIM M, KOJIMA N, et al. Exercise and nutritional supplementation on community-dwelling elderly Japanese women with sarcopenic obesity: a randomized controlled trial [J]. J Am Med Dir Assoc, 2016, 17(11): 1011-1019. DOI: 10.1016/j.jamda.2016.06.016.

[25] VASCONCELOS K S S, DIAS J M D, ARAÚJO M C, et al. Effects of a progressive resistance exercise program with high-speed component on the physical function of older women with sarcopenic obesity: a randomized controlled trial [J]. Braz J Phys Ther, 2016, 20(5): 432-440. DOI: 10.1590/bjpt-rbf.2014.0174.

[26] PARK J, KWON Y, PARK H. Effects of 24-week aerobic and resistance training on carotid artery intima-media thickness and flow velocity in elderly women with sarcopenic obesity [J]. J Atheroscler Thromb, 2017, 24(11): 1117-1124. DOI: 10.5551/jat.39065.

[27] LIAO C D, TSAUO J Y, LIN L F, et al. Effects of elastic resistance exercise on body composition and physical capacity in older women with sarcopenic obesity: a CONSORT-compliant prospective randomized controlled trial [J]. Medicine, 2017, 96(23): e7115. DOI: 10.1097/MD.0000000000007115.

[28] LIAO C D, TSAUO J Y, HUANG S W, et al. Effects of elastic band exercise on lean mass and physical capacity in older women with sarcopenic obesity: a randomized controlled trial [J]. Sci Rep, 2018, 8(1): 2317. DOI: 10.1038/s41598-018-20677-7.

[29] CHEN H T, CHUNG Y C, CHEN Y J, et al. Effects of different types of exercise on body composition, muscle strength, and IGF-1 in the elderly

with sarcopenic obesity [J]. J Am Geriatr Soc, 2017, 65(4): 827-832. DOI: 10.1111/jgs.14722.

[30] Li Shen, Huang Liping, Wang Lei, et al. Study on the intervention effects of 12-week aerobic walking combined with rapid strength training on elderly individuals with sarcopenic obesity [J]. Chinese Journal of Rehabilitation Medicine, 2020, 35(4): 420-426. DOI: 10.3969/j.issn.1001-1242.2020.04.007.

[31] Wang Lizhen, Guo Yingbin, Luo Junhong. Effects of home-based exercise training on elderly patients with sarcopenic obesity [J]. Chinese Journal of Rehabilitation Theory and Practice, 2019, 25(1): 90-96. DOI: 10.3969/j.issn.1006-9771.2019.01.015.

[32] KEMMLER W, TESCHLER M, WEISSENFELS A, et al. Whole-body electromyostimulation to fight sarcopenic obesity in community-dwelling older women at risk. Results of the randomized controlled FORMOsA-sarcopenic obesity study [J]. Osteoporos Int, 2016, 27(11): 3261-3270. DOI: 10.1007/s00198-016-3662-z.

[33] WATERS D L, AGUIRRE L, GURNEY B, et al. Effect of aerobic or resistance exercise, or both, on intermuscular and visceral fat and physical and metabolic function in older adults with obesity while dieting [J]. J Gerontol A Biol Sci Med Sci, 2022, 77(1): 131-139. DOI: 10.1093/gerona/glab111.

[34] CUI W L, LI D, YUE L J, et al. The effects of exercise dose on patients with Parkinson' s disease: a systematic review and meta-analysis of randomized controlled trials [J]. J Neurol, 2023, 270(11): 5327-5343. DOI: 10.1007/s00415-023-11887-9.

[35] Xia Yanxia. The Correlation Between Obesity and Sarcopenia in the Elderly and the Effects of Aerobic Exercise on Sarcopenic Obesity in Older Adults [D]. Wuhan: Wuhan Sports University, 2020.

[36] Ji Yelin, Zhang Peizhen. Research Progress on the Prevention and Control of Sarcopenic Obesity Through Exercise [J]. Chinese Journal of Public Health, 2023, 39(7): 935-941. DOI: 10.11847/zgggws1139913.

[37] GHIOTTO L, MUOLLO V, TATANGELO T, et al. Exercise and physical performance in older adults with sarcopenic obesity: a systematic review [J]. Front Endocrinol, 2022, 13: 913953. DOI: 10.3389/fendo.2022.913953.

[38] HITA-CONTRERAS F, BUENO-NOTIVOL J, MARTÍNEZ-AMAT A, et al. Effect of exercise alone or combined with dietary supplements on anthropometric and physical performance measures in community-dwelling elderly people with sarcopenic obesity: a meta-analysis of randomized controlled trials [J]. Maturitas, 2018, 116: 24-35. DOI: 10.1016/j.maturitas.2018.07.009.

[39] BOSELLO O, VANZO A. Obesity paradox and aging [J]. Eat Weight Disord, 2021, 26(1): 27-35. DOI: 10.1007/s40519-020-00915-y.

[40] ZHAO H T, CHENG R H, SONG G, et al. The effect of resistance

training on the rehabilitation of elderly patients with sarcopenia: a meta-analysis [J]. Int J Environ Res Public Health, 2022, 19(23): 15491. DOI: 10.3390/ijerph192315491.