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SYSTEMATIC REVIEW

Exercise and Nutritional Interventions for Muscle Strength, Physical Performance, and Body Composition Among Older Adults With Sarcopenia or Pre-Sarcopenia: A Network Meta-Analysis

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ABSTRACT

Objective: To compare the relative effects of exercise and nutritional interventions on muscle strength, physical performance, muscle mass, and body composition-related outcomes in older adults with sarcopenia or pre-sarcopenia using network meta-analysis.

Methods: PubMed, Embase, the Cochrane Library, and Web of Science were searched from inception to August 8, 2026. Randomized controlled trials (RCTs) comparing exercise, nutritional, or combined interventions with control strategies in older adults with sarcopenia or pre-sarcopenia were included. A frequentist network meta-analysis compared four intervention nodes (Control, Exercise, Nutrition, and Combined). Risk of bias was assessed with RoB 2, and certainty of evidence with CINeMA.

Results: Sixty-five reports representing 57 RCTs and 6017 participants were included. Compared with Control, Combined, Nutrition, and Exercise improved handgrip strength, with the largest estimate for Combined (mean difference [MD] 4.29 kg, 95% confidence interval [CI], 2.50–6.07; *p*-score 0.877). For physical function, Exercise improved the Timed Up and Go test (TUG; MD 1.19 s, 95% CI, 0.72–1.66) and ranked highly for gait speed (MD 0.11 m/s, 95% CI, 0.06–0.17). For appendicular skeletal muscle mass index (ASMI), Combined, Exercise, and Nutrition increased ASMI, with Combined ranked highest (MD 0.32 kg/m^2, 95% CI, 0.17–0.48; *p*-score 0.831). Overall certainty of evidence was limited according to CINeMA.

Conclusions: Exercise and nutritional strategies showed different relative effects across clinical outcomes in older adults with sarcopenia or pre-sarcopenia. Combined exercise and nutrition ranked more favorably for selected muscle-related outcomes, whereas exercise showed a more consistent pattern of benefit for physical performance. These findings require confirmation in high-quality trials because the overall certainty of evidence was limited.

1 | Introduction

Sarcopenia is an age-related progressive syndrome characterized by declines in skeletal muscle mass, muscle strength, and physical function, and is an important health challenge in aging societies worldwide [1]. Its prevalence is approximately 5%–13% among adults aged 60 years or older and may approach 50% in those aged over 80 years [2]. Sarcopenia impairs daily function

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and quality of life and is associated with falls, fractures, hospitalization, and mortality [3].

Current diagnostic frameworks are based on international consensus criteria, including those of the Asian Working Group for Sarcopenia (AWGS) and the European Working Group on Sarcopenia in Older People (EWGSOP) [4]. These frameworks recognize sarcopenia as a multidimensional condition involving muscle strength, physical performance, and muscle mass rather than low muscle mass alone. Intervention effects should therefore be evaluated across multiple clinically relevant outcomes.

Exercise is widely considered a key strategy for managing sarcopenia. Resistance, multicomponent, aerobic, and balance training have all been used in this population. Previous systematic reviews and meta-analyses suggest that exercise can improve handgrip strength, physical performance, and selected body-composition measures [5]. However, the relative effects of different exercise modes, programs, and doses remain uncertain.

Nutritional intervention is another important component of sarcopenia management. Protein and amino-acid supplementation provides substrates for muscle protein synthesis, and branched-chain amino acids (BCAA) such as leucine may stimulate relevant anabolic pathways [6]. Vitamin D, β-hydroxy-β-methylbutyrate (HMB), creatine, ω-3 fatty acids, and other supplements have also been studied for muscle health in older adults [7, 8]. Exercise combined with nutritional support is biologically plausible, but trial results are inconsistent and the relative effects of available strategies remain uncertain [9].

As additional randomized controlled trials (RCTs) are published, the evidence base for exercise, nutrition, and their combination in sarcopenia continues to expand. Previous reviews and network meta-analyses have informed this field, but their intervention classifications and outcome scopes differ. An updated comparison across muscle strength, physical performance, and muscle mass is therefore warranted.

We conducted a network meta-analysis to compare the relative effects of exercise and nutritional strategies on muscle strength, physical performance, muscle mass, and body composition-related outcomes in older adults with sarcopenia.

2 | Methods

2.1 | Study Design

This network meta-analysis was designed and conducted in accordance with the PRISMA extension statement for network meta-analysis and internationally recognized reporting and methodological standards [10] (Supplementary Table S1). The protocol was prospectively registered in PROSPERO (CRD420251159157).

2.2 | Search Strategy

A systematic search of PubMed, Embase, the Cochrane Library, and Web of Science was conducted on August 8, 2026. This was the final search date and covered records from database inception without restrictions on language or publication status. Potentially eligible non-English reports were machine-translated and key information was reviewed by the investigators. The full search strategy is provided in Supplementary Table S2.

Medical Subject Headings and free-text terms were used. Core terms included "sarcopenia," "exercise," "physical activity," "resistance training," "nutrition," "protein supplementation," "dietary intervention," "older adults," "elderly," and "randomized controlled trial," together with their synonyms [11] (Supplementary Table S2). Reference lists of relevant systematic reviews and meta-analyses were also screened manually.

2.3 | Eligibility Criteria

Eligible studies were RCTs enrolling adults aged ≥60 years with sarcopenia defined according to AWGS, EWGSOP, or another recognized consensus criterion. Studies of pre-sarcopenia, defined under earlier diagnostic frameworks by explicit and reproducible thresholds for low muscle mass, were also eligible. Interventions were structured exercise, clearly specified nutritional interventions, or their combination; comparators were usual care, no intervention, placebo, health education, or another eligible strategy.

Studies had to report at least one prespecified outcome domain: muscle strength, including handgrip strength; physical function, including TUG and gait speed; or muscle mass and body composition, including ASMI, appendicular skeletal muscle mass (ASM), body mass index (BMI), and body weight. Gait speed and TUG were both physical-function outcomes; ASMI and ASM represented muscle mass, whereas BMI and body weight were ancillary body-composition outcomes and were not used alone to determine improvement in sarcopenia.

2.4 | Study Selection and Data Extraction

Study selection and data extraction were performed independently by two reviewers (HXY and QW). Disagreements were resolved by discussion or consultation with a third reviewer (BQW). A standardized form captured study characteristics: participant characteristics, including number of women; intervention setting; exercise mode, frequency, intensity; nutritional component, dose, and duration; outcome data; and information relevant to study quality.

2.5 | Risk-of-Bias and Certainty-of-Evidence Assessment

Methodological quality was assessed with the Cochrane Risk of Bias 2 tool (RoB 2) [12], which covers the randomization process, deviations from intended interventions, missing outcome data, outcome measurement, and selection of the reported result. Domains were judged as low risk, some concerns, or high risk.

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Certainty of evidence was evaluated using the Confidence in Network Meta-Analysis (CINeMA) framework [13]. CINeMA assesses within-study bias, reporting bias, indirectness, imprecision, heterogeneity, and incoherence. Network comparisons were rated as high, moderate, low, or very low certainty after consideration of all six domains.

2.6 | Intervention Node Definitions

Based on the core components of each intervention, all eligible interventions were classified into four mutually exclusive nodes: Control, Exercise, Nutrition, and Combined.

Control comprised interventions without structured exercise or active nutritional supplementation, including usual care, no intervention, health education, attention control, and placebo. Exercise comprised structured exercise without protocolized nutritional supplementation, including resistance, multicomponent, aerobic, balance, functional, and vibration training. Nutrition comprised active nutritional supplementation without structured exercise, including protein, whey protein, amino acids, BCAA, HMB, vitamin D, creatine, ω-3 fatty acids, and other supplements with clearly defined components. Combined comprised interventions incorporating both structured exercise and active nutritional supplementation.

In studies with multiple eligible intervention groups, each group was assigned separately to the corresponding node according to these prespecified criteria.

2.7 | Statistical Analysis

A frequentist random-effects network meta-analysis was performed using the netmeta package (version 3.6-1) in R (version 4.5.2), integrating direct and indirect evidence to estimate relative effects between interventions [14].

Continuous outcomes were expressed as mean differences (MDs) with 95% CIs in their original units. Standardized MDs were not interpreted in clinical units. Because a shorter TUG completion time indicates better physical function, TUG effects were reverse-coded before analysis; positive TUG values in the text, forest plots, and league tables indicate a shorter completion time and improved physical function.

Network geometry was displayed using network plots, in which nodes represented intervention strategies, node size reflected sample size, and edges indicated direct comparisons. All analyses used the four prespecified intervention nodes.

Interventions were ranked using *p*-scores, which range from 0 to 1, with higher values indicating a more favorable relative ranking [15].

Consistency was assessed using global inconsistency testing and node-splitting analyses comparing direct and indirect evidence. Between-study heterogeneity was quantified using I^2, with $I^2 > 50\%$ considered substantial heterogeneity [16].

For multi-arm trials, correlations between intervention groups were retained to avoid double counting.

The following sensitivity analyses were prespecified: exclusion of studies at overall high risk of bias; restriction to populations defined using strict sarcopenia diagnostic criteria; and exclusion of studies using specialized exercise interventions, such as whole-body electrical stimulation or whole-body vibration.

Potential small-study effects and publication bias were assessed using comparison-adjusted funnel plots and Egger tests [17].

3 | Results

3.1 | Literature Screening Process

The database search yielded 8532 records: 1521 from PubMed, 2025 from Web of Science, 2227 from the Cochrane Library, and 2759 from Embase. After 2464 duplicates were removed, 6068 records were screened by title and abstract. Of 102 full-text reports assessed for eligibility, 37 were excluded, mainly because the study population or definition of sarcopenia did not meet the prespecified criteria. Overall, 65 reports representing 57 [18–74] independent RCTs were included (Figure 1).

3.2 | Characteristics of Included Studies

Fifty-seven independent RCTs [18–74], involving 6017 participants, were included. Studies were conducted in 16 countries or regions and across community, outpatient, hospital, residential-care, and multicenter settings.

All included studies enrolled adults aged ≥ 60 years with sarcopenia defined according to AWGS, EWGSOP, or other recognized criteria. Some studies enrolled participants with pre-sarcopenia defined by explicit and reproducible thresholds for low muscle mass.

Under the prespecified node classification, studies evaluated Control, Exercise, Nutrition, and Combined interventions. Exercise interventions included resistance, multicomponent, aerobic, balance, functional, and vibration training. Nutritional interventions included protein, whey protein, amino acids, HMB, vitamin D, creatine, omega-3 fatty acids, and other specified supplements. Intervention duration ranged from 30 days to 36 months. Detailed characteristics are provided in Supplementary Tables S4 and S5.

3.3 | Risk of Bias Assessment

Using the Cochrane Risk of Bias 2.0 tool, 17 of the 57 RCTs were rated as low risk, 35 as having some concerns, and 5 as high risk (Figure 2; Supplementary Table S3).

All studies were judged to be at low risk for measurement of the outcome. Concerns in other domains primarily involved the randomization process, deviations from intended interventions, and selection of the reported result.

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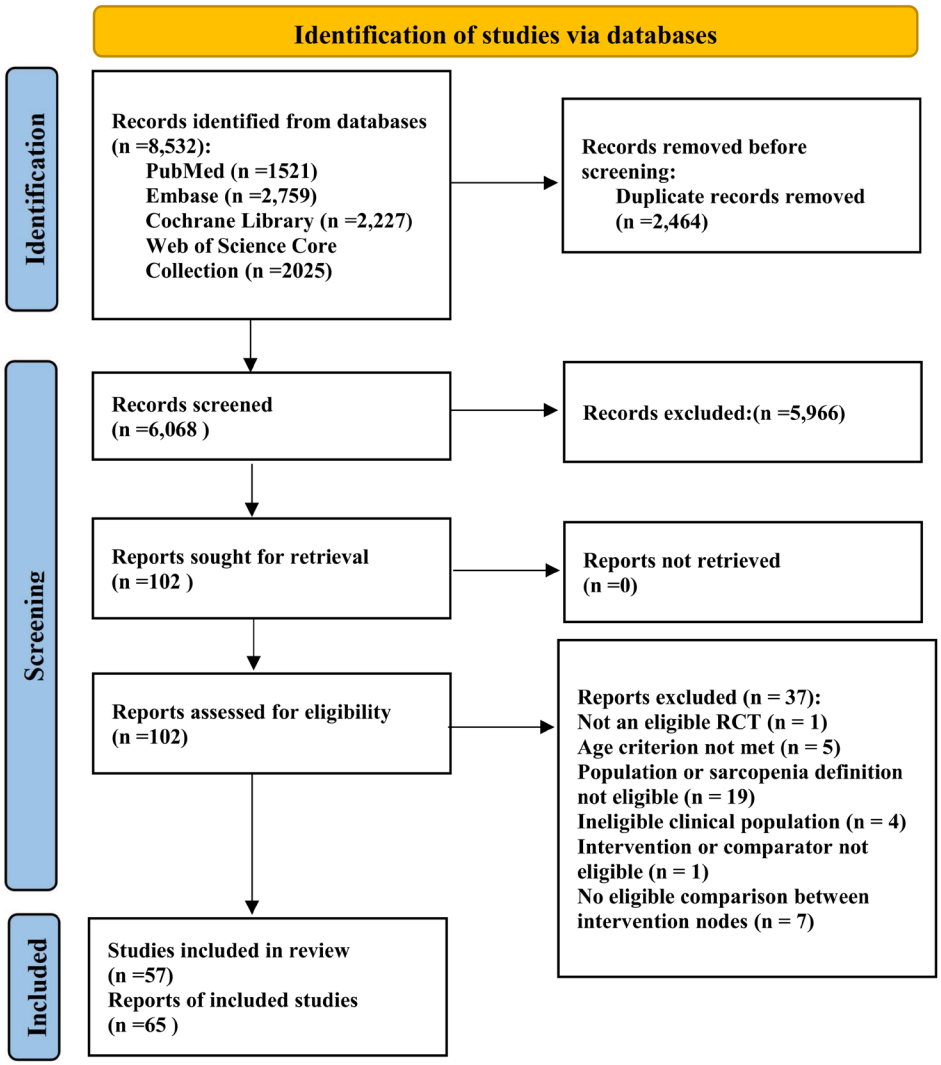


FIGURE 1 | PRISMA 2020 flow diagram of study selection.

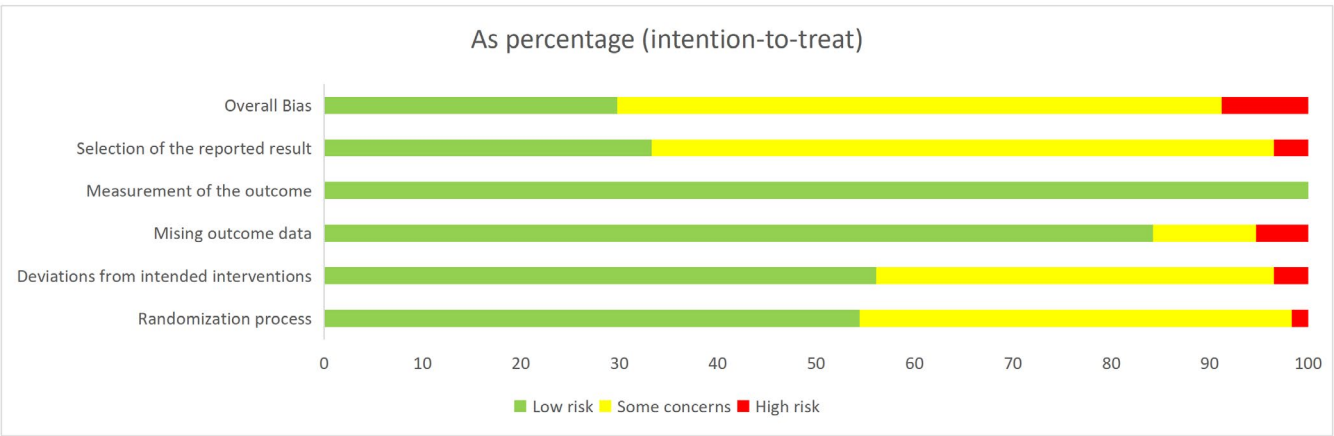


FIGURE 2 | Risk-of-bias summary of the included randomized controlled trials.

3.4 | Network Geometry

The network comprised four prespecified intervention nodes: Control, Exercise, Nutrition, and Combined (Figure 3). All outcome-specific networks were connected and included all four interventions. The network meta-analysis assessed three prespecified outcome domains: muscle strength, physical performance, and body composition-related outcomes.

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3.5 | Effects of Interventions on Muscle Strength

3.5.1 | Handgrip Strength

The handgrip-strength network included 26 RCTs and 2141 participants (Figure 3A).

Compared with Control, Combined, Nutrition, and Exercise improved handgrip strength. The MDs were 4.29 kg (95% CI, 2.50–6.07) for Combined, 3.64 kg (95% CI, 2.09–5.19) for Nutrition, and 3.12 kg (95% CI, 2.02–4.22) for Exercise (Figure 4A; Supplementary Tables S6 and S7).

Combined ranked highest by *p*-score (0.877), followed by Nutrition (0.665), Exercise (0.458), and Control (Supplementary Table S7).

3.6 | Effects of Interventions on Physical Performance

3.6.1 | Timed Up and Go Test

The TUG network included 10 RCTs and 658 participants (Figure 3B).

Compared with Control, Exercise improved the TUG score (MD = 1.19 s, 95% CI, 0.72–1.66), whereas Combined (MD = −0.29 s, 95% CI, −1.18 to 0.60) and Nutrition (MD = −0.02 s, 95% CI, −0.83 to 0.79) showed no statistically significant differences (Figure 4B; Supplementary Tables S6 and S7).

Exercise ranked highest by *p*-score (0.997), followed by Control, Nutrition, and Combined (Supplementary Table S7).

3.6.2 | Gait Speed

The gait-speed network included 17 RCTs and 1350 participants (Figure 3C).

Compared with Control, Exercise, Nutrition, and Combined improved gait speed. The MDs were 0.11 m/s (95% CI, 0.06–0.17) for Exercise, 0.11 m/s (95% CI, 0.02–0.19) for Nutrition, and 0.09 m/s (95% CI, 0.01–0.17) for Combined (Figure 4C; Supplementary Tables S6 and S7).

Exercise ranked highest by *p*-score (0.765), followed by Nutrition, Combined, and Control (Supplementary Table S7).

3.7 | Effects of Interventions on Body Composition-Related Outcomes

3.7.1 | Appendicular Skeletal Muscle Mass Index

The ASMI network included 24 RCTs and 1664 participants (Figure 3D).

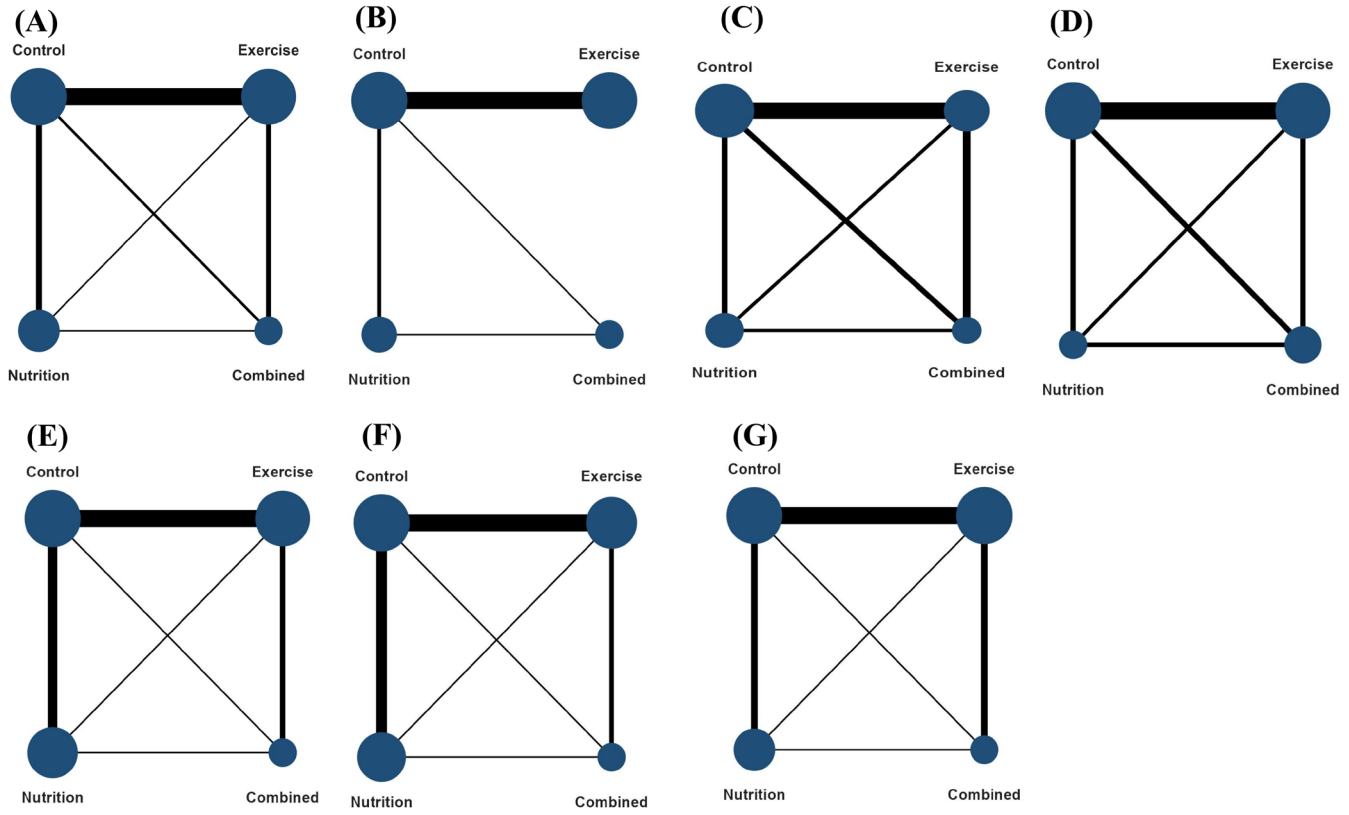


FIGURE 3 | Network plots of interventions across outcomes: (A) Hand grip strength. (B) Timed Up and Go test (TUG). (C) Gait speed. (D) Appendicular skeletal muscle mass index (ASMI). (E) Appendicular skeletal muscle mass (ASM). (F) Body mass index (BMI). (G) Body weight.

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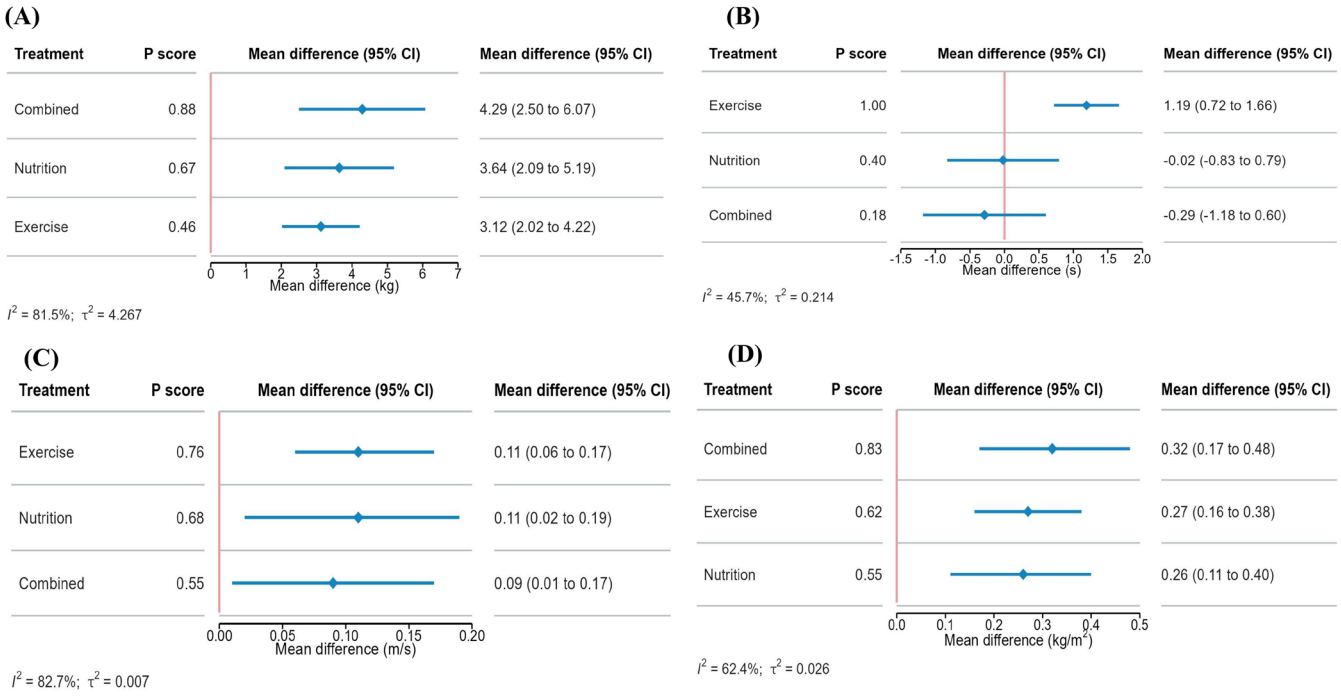


FIGURE 4 | Forest plots of network meta-analysis across outcomes: (A) Hand Grip Strength. (B) Timed Up and Go Test (TUG). (C) Gait Speed. (D) Appendicular Skeletal Muscle Mass Index (ASMI).

Compared with Control, Combined, Exercise, and Nutrition increased ASMI. The MDs were 0.32 kg/m^2 (95% CI, 0.17–0.48) for Combined, 0.27 kg/m^2 (95% CI, 0.16–0.38) for Exercise, and 0.26 kg/m^2 (95% CI, 0.11–0.40) for Nutrition (Figure 4D; Supplementary Tables S6 and S7). Combined ranked highest by *p*-score (0.831), followed by Exercise, Nutrition, and Control (Supplementary Table S7).

3.7.2 | Appendicular Skeletal Muscle Mass

The ASM network included 9 RCTs and 651 participants (Figure 3E).

Compared with Control, Combined (MD = 0.97 kg, 95% CI, 0.21–1.72) and Nutrition (MD = 0.50 kg, 95% CI, 0.04–0.97) increased ASM, whereas Exercise showed no statistically significant difference (MD = 0.12 kg, 95% CI, −0.38 to 0.62) (Figure 5A; Supplementary Tables S6 and S7). Combined ranked highest by *p*-score (0.953), followed by Nutrition, Exercise, and Control (Supplementary Table S7).

3.7.3 | Body Mass Index

The BMI network included 10 RCTs and 574 participants (Figure 3F).

None of the three active interventions differed significantly from Control for BMI: Combined, MD = 0.92 kg/m^2 (95% CI, −0.23 to 2.06); Nutrition, MD = 0.37 kg/m^2 (95% CI, −0.25 to 0.98); and Exercise, MD = −0.23 kg/m^2 (95% CI, −0.93 to 0.47) (Figure 5B; Supplementary Tables S6 and S7). Combined ranked highest, followed by Nutrition, Control, and Exercise (Supplementary Table S7).

3.7.4 | Body Weight

The body-weight network included 11 RCTs and 596 participants (Figure 3G).

None of the three active interventions differed significantly from Control for body weight: Combined, MD = 2.88 kg (95% CI, −0.30 to 6.06); Nutrition, MD = 1.78 kg (95% CI, −0.26 to 3.83); and Exercise, MD = −1.39 kg (95% CI, −3.31 to 0.53) (Figure 5C; Supplementary Tables S6 and S7). Combined ranked highest, followed by Nutrition, Control, and Exercise (Supplementary Table S7).

3.8 | Heterogeneity and Inconsistency

Heterogeneity varied across outcome networks, with I^2 values ranging from 28.7% to 82.7%. Heterogeneity was high for handgrip strength (I^2 = 81.5%) and gait speed (I^2 = 82.7%), relatively high for ASMI (I^2 = 62.4%) and BMI (I^2 = 63.1%), moderate for TUG (I^2 = 45.7%), and low for ASM (I^2 = 33.9%) and body weight (I^2 = 28.7%) (Supplementary Table S8).

Global inconsistency was not statistically significant for handgrip strength (p = 0.071), TUG (p = 0.230), gait speed (p = 0.123), BMI (p = 0.491), or body weight (p = 0.153), but was significant for ASMI (p < 0.001) and ASM (p = 0.012).

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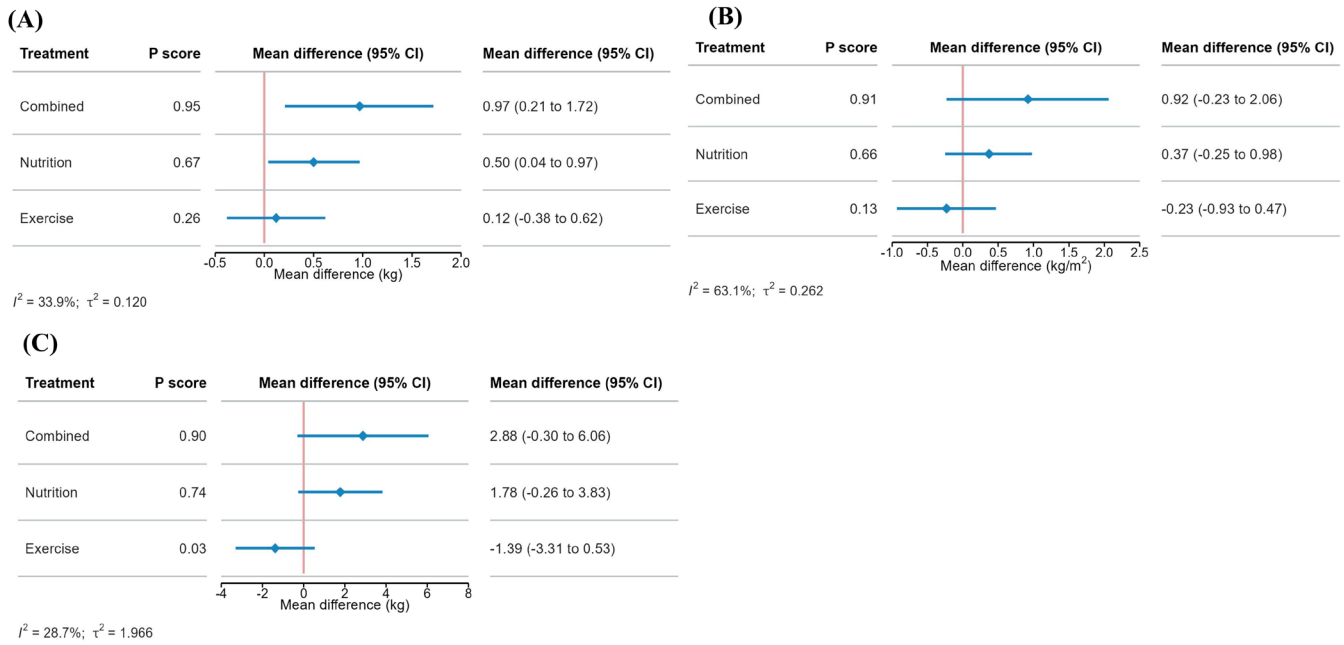


FIGURE 5 | Forest plots of network meta-analysis across outcomes: (A) Appendicular Skeletal Muscle Mass (ASM). (B) Body Mass Index (BMI). (C) Body Mass.

Node-splitting analysis identified statistically significant differences between direct and indirect evidence for Exercise versus Nutrition in the ASMI ($p = 0.050$) and ASM ($p = 0.033$) networks. No significant local inconsistency was detected for other comparisons (Supplementary Table S9).

3.9 | Sensitivity Analyses

Three prespecified sensitivity analyses were generally consistent with the primary analyses (Supplementary Table S13; Supplementary Figure S2). Excluding studies at high overall risk of bias did not materially change the direction of the main effect estimates. Restricting analyses to trials using strict sarcopenia diagnostic criteria yielded broadly consistent results. Excluding studies of specialized exercise interventions, including whole-body electrical stimulation or whole-body vibration, did not materially alter the network structure or main effect estimates.

3.10 | Small-Study Effects

Comparison-adjusted funnel plots and tests for small-study effects showed no clear evidence of small-study effects across outcome networks (Supplementary Figure S1).

3.11 | Confidence in the Evidence

Of 42 network comparisons, CINeMA rated 7 as moderate confidence, 20 as low confidence, and 15 as very low confidence (Supplementary Tables S10–S12).

Confidence ratings varied by outcome. Comparisons for handgrip strength, gait speed, ASMI, and BMI were predominantly rated as low confidence; those for TUG and body weight as moderate confidence; and those for ASM as low or very low confidence depending on the specific comparison.

4 | Discussion

4.1 | Main Findings

This network meta-analysis compared exercise, nutrition, and combined interventions across key clinical outcomes in older adults with sarcopenia. Effects varied across muscle strength, physical performance, and body composition-related outcomes. Combined interventions ranked relatively high for muscle-related outcomes, including handgrip strength, ASMI, and ASM, whereas exercise showed more favorable effects on physical performance outcomes, including TUG and gait speed. No clear differences among active interventions were observed for BMI or body weight. These findings suggest that intervention effects may vary according to the clinical outcome targeted, with different strategies potentially influencing different dimensions of sarcopenia. However, because confidence in the evidence was limited for some comparisons, the ranking results should be interpreted cautiously and require confirmation in further high-quality studies.

4.2 | Effects on Muscle Strength

Combined exercise and nutrition had the most favorable relative ranking for handgrip strength, followed by Nutrition and Exercise. All three active strategies increased handgrip strength versus Control, suggesting that exercise and nutrition may each improve muscle strength in older adults with sarcopenia.

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Resistance exercise provides mechanical stimuli for adaptation, whereas adequate protein and related nutritional intake provide substrates for muscle protein synthesis [75, 76].

4.3 | Effects of Interventions on Physical Performance

Exercise ranked relatively high for physical performance outcomes, with favorable effects on TUG and gait speed. Compared with Control, Exercise improved TUG (MD = 1.19 s, 95% CI, 0.72–1.66) and ranked highly for gait speed. Although combined exercise and nutritional interventions performed well for muscle-related outcomes, they did not show a clear advantage over exercise alone for functional outcomes. These findings suggest that the relative effects of intervention strategies may vary according to the clinical domain assessed.

Physical performance is influenced not only by muscle strength and muscle mass but also by neuromuscular coordination, balance, and mobility [77]. Exercise training, particularly programs incorporating resistance and balance training, may improve muscle activation, functional capacity, mobility, and physical performance in older adults [78]. Thus, for patients with sarcopenia characterized primarily by impaired walking ability or mobility limitations, structured exercise may remain important for improving functional status, while nutritional support may contribute to overall muscle health as part of comprehensive management.

4.4 | Effects of Interventions on Body Composition-Related Outcomes

Effects on body composition-related outcomes varied across intervention strategies. For muscle-specific measures such as ASMI and ASM, combined interventions ranked relatively high, and nutritional interventions also showed favorable trends, suggesting that both exercise stimulation and nutritional support may contribute to improvements in muscle-related body composition. Muscle mass maintenance and recovery depend on both mechanical stimulation and nutritional supply; exercise promotes muscle adaptation, whereas adequate protein and specific nutrients support muscle protein synthesis [79]. Combined exercise and nutritional strategies may therefore have potential value for older adults with sarcopenia characterized predominantly by low muscle mass.

No clear effects of the active interventions were observed for BMI or body weight, suggesting that these measures may be less sensitive for evaluating sarcopenia interventions. Neither BMI nor body weight distinguishes lean from adipose tissue, and body weight may remain stable despite gains in muscle mass. The principal goals of sarcopenia treatment are improvements in muscle mass, strength, and function rather than weight gain alone. Recent randomized trials similarly found improvements in gait speed, handgrip strength, and other functional outcomes with combined exercise and nutritional interventions, while effects on some body composition measures remained limited [80]. Muscle-specific measures may therefore be more informative when evaluating treatment effects.

4.5 | Clinical Implications

Intervention selection should consider each patient's predominant clinical presentation and therapeutic goals. Combined exercise and nutrition may be of potential value for low muscle strength or muscle mass, whereas structured exercise may be particularly important for reduced mobility and functional limitation. Effects nonetheless differ across outcomes.

Exercise training and nutritional support should be regarded as important components of comprehensive sarcopenia management. Future research should clarify how patient characteristics modify intervention benefits to optimize individualized strategies.

4.6 | Strengths and Limitations

This study included 57 RCTs and used network meta-analysis to compare exercise, nutrition, and combined interventions across multiple clinical outcomes. It evaluated muscle strength, physical function, and body composition-related outcomes and used RoB 2 and CINeMA to improve the transparency of interpretation.

Several limitations should be considered. Exercise mode, nutritional composition, dose, intervention duration, and baseline characteristics varied across studies. Clinical heterogeneity within nodes may weaken exchangeability and affect network estimates. The ASMI and ASM networks showed inconsistency, several networks had substantial heterogeneity, and most comparisons were rated as low or very low certainty; *p*-scores should not be regarded as definitive treatment rankings. The four-node network cannot test interaction or synergy between exercise and nutrition. Although the proportion of women was extracted, many trials did not report sex by intervention group or data suitable for interaction analysis; sex-stratified analyses were not performed. Follow-up was generally limited, and long-term effects remain uncertain.

5 | Conclusion

Exercise and nutritional strategies showed different relative effects in older adults with sarcopenia. Combined exercise and nutrition ranked more favorably for handgrip strength and skeletal muscle-related outcomes, whereas exercise performed more favorably for physical-function outcomes. Intervention selection may need to be tailored to clinical presentation and therapeutic goals. However, heterogeneity was present in several networks, and overall certainty was limited. Well-designed trials with standardized protocols and longer follow-up are needed to clarify longer-term benefits and appropriate target populations.

Author Contributions

HongXia Yang: conceptualized the study, conducted literature search, screening, data extraction, risk of bias assessment, statistical analysis, result interpretation, and drafted the manuscript. **Qian Wang:** contributed to the study's conceptualization and conducted literature search, screening, data extraction, risk of bias assessment,

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and result interpretation. **BiQing Wang:** conducted literature search, screening, data extraction, risk of bias assessment, and result interpretation. **JunNan Zhao:** performed risk of bias assessment, result interpretation, and data analysis. **XiaoLei Xie:** conducted literature screening and data extraction. **FengQin Xu, Ning Xiao, and Ping Zhang:** supervised the study and made significant revisions to the manuscript. All authors have carefully reviewed and approved the final manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

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

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** ggi70897-sup-0001-SupinfoS1.pdf. **Supplementary Table S1:** PRISMA NMA checklist. **Supplementary Table S2:** Search strategies. **Supplementary Table S3:** Risk-of-bias assessment using the Cochrane RoB 2.0 tool (study-level). **Supplementary Table S4:** Characteristics of included RCTs: studies and participants. **Supplementary Table S5:** Characteristics of included RCTs: interventions and outcomes. **Supplementary Table S6:** League tables for all outcomes. **Supplementary Table S7:** Treatment rankings and *p*-scores by outcome. **Supplementary Table S8:** Heterogeneity and global inconsistency statistics. **Supplementary Table S9:** Local inconsistency assessment by node-splitting. **Supplementary Table S10:** Clinical importance and equivalence margins for CINeMA imprecision assessment. **Supplementary Table S11:** Contribution matrices for the network meta-analyses. **Supplementary Table S12:** CINeMA domain assessments and confidence ratings for network estimates. **Supplementary Table S13:** Summary of prespecified sensitivity analyses. **Supplementary Figure S1:** Comparison-adjusted funnel plots for all outcomes. **Supplementary Figure S2:** Sensitivity analyses for all outcomes.

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