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Resistance training for sarcopenia prevention in older adults: a systematic review of conventional and technology-enabled programmes

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ABSTRACT

Sarcopenia, the age-related loss of skeletal muscle mass, strength, and physical function, is a growing public health concern that undermines independence and increases the risk of falls, disability, and mortality in ageing populations. This systematic literature review examined the effectiveness of resistance training for preventing sarcopenia and preserving muscle outcomes in older adults, and the programme characteristics associated with better results. The review followed the PRISMA 2020 framework. A structured search of the Scopus database, restricted to English-language journal articles published between 2016 and 2025, initially identified 296 records. After removal of duplicates, title and abstract screening, and full-text eligibility assessment against predefined criteria, 15 controlled intervention studies were included in the synthesis. A thematic synthesis showed that resistance and strength training consistently improved handgrip strength, lower-limb force, and physical performance, with more variable effects on muscle mass indices. Effective programmes typically involved supervised or technology-supported training two to three times weekly over 8 to 24 weeks, and combining training with protein supplementation appeared to enhance muscle outcomes. The findings support resistance training as a central preventive strategy while highlighting heterogeneity in dosing, populations, and outcome measures. Future trials should standardise sarcopenia outcomes and clarify optimal training parameters across diverse older populations.

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Introduction

Global population ageing has positioned sarcopenia among the most pressing challenges for geriatric and public health systems. Sarcopenia is characterised by the progressive and generalised loss of skeletal muscle mass, strength, and function, and its prevalence rises steeply with advancing age (Cui et al., 2023; Scott et al., 2016). The condition reflects a complex interaction of neuromuscular decline, chronic low-grade inflammation, hormonal change, physical inactivity, and inadequate nutrition, which together accelerate a metabolic "war of attrition" that erodes physical capacity (Fountain et al., 2024; Luk & Chan, 2022). As the proportion of older adults expands worldwide, the individual and societal costs of untreated muscle decline are expected to grow, making prevention a strategic priority rather than a secondary concern.

The clinical consequences of sarcopenia extend well beyond reduced strength. Low muscle mass and poor physical performance are strongly associated with falls, frailty, loss of independence, institutionalisation, and premature mortality, and they interact bidirectionally with chronic diseases such as type 2 diabetes (Scott et al., 2016; Machii et al., 2020). The burden is especially pronounced in institutional settings, where a substantial proportion of residents already meet sarcopenia criteria (Yang et al., 2019). Consensus panels across several regions have therefore emphasised early identification and management, positioning muscle health as a modifiable determinant of healthy ageing (Zanker et al., 2023; Lim et al., 2022). Because pharmacological options remain limited, non-pharmacological strategies that can be delivered at scale in community and clinical settings are central to any effective preventive agenda.

Among these strategies, exercise, and resistance training in particular, is repeatedly identified as the cornerstone of sarcopenia prevention and management. Expert recommendations converge on progressive resistance training as the most robust stimulus for preserving muscle mass and strength in later life, often supported by adequate protein and micronutrient intake (Izquierdo et al., 2021; Bosaeus & Rothenberg, 2016). Controlled trials have shown that resistance exercise, alone or combined with nutritional supplementation, can increase skeletal muscle mass index, handgrip strength, and gait speed in older adults (Mori & Tokuda, 2018; Osuka et al., 2017). Nutritional adjuncts, including whey protein and omega-3 fatty acids, have been proposed to potentiate these adaptations, although their independent contribution remains debated (Dupont et al., 2019). Mechanistic work further indicates that long-term resistance and endurance training are associated with favourable skeletal-muscle gene-expression profiles in older adults, pointing to durable biological adaptation (Bolotta et al., 2020).

Recent research has expanded the delivery of resistance training beyond supervised gymnasium settings. Home-based programmes, tele-rehabilitation delivered through mobile applications, virtual reality exercise, wearable-supported training, and neuromuscular electrical stimulation have all been examined as means of improving access, adherence, and scalability (Zhang et al., 2025; Chitjamnogchai et al., 2025; Ferrari et al., 2024; Thapa et al., 2023). These technological approaches respond to well-documented barriers such as transport, supervision cost, and limited rehabilitation capacity, and they signal a methodological shift toward more flexible, patient-centred models of exercise prescription for older populations.

Despite this progress, important gaps persist. The optimal characteristics of resistance training programmes, including intensity, frequency, session duration, exercise selection, and delivery format, remain insufficiently defined for sarcopenia prevention specifically, and trials differ widely in dose and supervision (Cebrià I Iranzo et al., 2018; Saengrut et al., 2022). Neuro-rehabilitation and institutional contexts add further complexity, since the muscle response to training can vary with baseline function and comorbidity (Lathuilière et al., 2019). This heterogeneity complicates the translation of trial evidence into standardised, actionable guidance for practitioners.

A second set of limitations is theoretical and methodological. Many intervention studies rely on short durations, small samples, or heterogeneous sarcopenia definitions, and an increasing number are conducted in specific clinical populations such as stroke, dementia, or post-surgical patients, where the isolation of a preventive effect is difficult (Feng et al., 2024; Qaisar et al., 2024; Mendes et al., 2025). Outcome measurement is inconsistent, with muscle mass, strength, and physical performance not always reported together, which weakens comparability across studies (Pereira et al., 2025). These issues limit the strength of causal inference and hinder cumulative knowledge building.

Given these tensions, an updated synthesis is warranted. Existing reviews and guidelines have addressed broad exercise or nutrition recommendations, or have focused on particular subgroups such as menopausal women, but few have systematically consolidated recent controlled evidence on resistance training for sarcopenia prevention across diverse older populations while explicitly mapping programme characteristics (Tan et al., 2023; Lewis et al., 2025; Maier et al., 2023; Volkert et al., 2024; Kuzuya, 2022). Consolidating this literature is timely because the rapid emergence of technology-enabled delivery and combined interventions has changed the evidence landscape within a short period.

This review therefore addresses the following question. RQ1: How effective is resistance training in preventing sarcopenia and preserving muscle mass, strength, and physical function in older adults? By synthesising recent controlled trials, the review clarifies the direction and consistency of effects across multiple muscle and functional outcomes, offering an evidence-based appraisal of resistance training as a preventive strategy.

The review also examines programme design. RQ2: Which characteristics of resistance training programmes, such as exercise type, frequency, intensity, duration, and delivery format, are associated with better muscle and functional outcomes in older adults? Answering this question contributes a structured mapping of intervention parameters to outcomes, and the review's novelty lies in integrating conventional and technology-enabled resistance training evidence within a single PRISMA-guided synthesis to inform both practice and future trial design.

Method

Research Design and Framework

This study adopted a systematic literature review design to identify, appraise, and synthesise controlled evidence on resistance training for sarcopenia prevention in older adults. The systematic review approach was selected because it provides a transparent, reproducible method for consolidating fragmented intervention evidence and for reducing selection and reporting bias relative to narrative reviews (Tranfield et al., 2003). The review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement, which structures the identification, screening, eligibility, and inclusion phases and standardises the reporting of study selection (Page et al., 2021).

Review Framework and Search Strategy

Because the review addresses the effectiveness of a deliberate intervention, the Population, Intervention, Comparison, and Outcome (PICO) framework was used to structure the search rather than frameworks intended for associational or qualitative questions. The population comprised older adults, including community-dwelling and clinical subgroups; the intervention was resistance or strength training, delivered alone or as the identifiable core of a combined programme; the comparison was usual care, no training, or an alternative exercise modality; and the outcomes were muscle mass, muscle strength, physical function, or sarcopenia-related indices. Each element was translated into a cluster of keywords and synonyms that were combined with Boolean operators. The following search string was executed in Scopus:

> (sarcopenia AND ("resistance training" OR "strength training") AND ("older adults" OR elderly OR aged) AND (prevention OR preventive))

The search was applied to the title, abstract, and keyword fields using the TITLE-ABS-KEY field code, which restricts retrieval to records in which the concepts appear in indexed metadata. Truncation and wildcard operators were used where appropriate to capture grammatical variants, for example, terms based on the stem "prevent" to retrieve "prevention" and "preventive." The string was piloted and refined iteratively; overly broad formulations that returned large volumes of tangentially related records were narrowed by anchoring the search on the concept of sarcopenia together with an explicit resistance or strength training term.

Databases and Information Sources

Scopus served as the single primary bibliographic database for this review, selected for its broad multidisciplinary coverage of biomedical, sport science, and gerontology journals and its structured metadata, which support reproducible record management. The search was executed and the records were exported for screening in September 2025. Because a single database was used, no cross-database duplication was expected, and no additional database or grey-literature sources were incorporated into the selection process for this review. The search was executed on 15 September 2025, covering publications from 1 January 2016 to 31 December 2025. Single-database searching was a deliberate scoping decision: Scopus was selected for its comprehensive coverage of gerontology, sport science, and biomedical journals, its structured TITLE-ABS-KEY field coding, and its consistent metadata export. The limitation of single-database retrieval is acknowledged in the limitations section; supplementary searching of PubMed/MEDLINE, CINAHL, and Web of Science is recommended for future reviews seeking maximum retrieval completeness, particularly for clinical trial registries and grey literature. No grey literature, preprint repositories, or unpublished data were incorporated.

Eligibility Criteria

Studies were assessed against predefined inclusion and exclusion criteria. Only English-language journal articles reporting primary controlled intervention data, published between 2016 and 2025, were eligible. Reviews, guidelines, consensus statements, study protocols and design papers without outcome data, observational studies without an intervention, animal studies, and studies whose intervention could not be attributed to resistance or strength training were excluded. The full criteria are presented in Table 1. For the purposes of this review, "older adults" was operationalised as individuals aged 60 years or older, consistent with the age thresholds used in the majority of sarcopenia consensus statements (EWGSOP2: ≥60 years; Asian Working Group for Sarcopenia: ≥60 years). Studies reporting mixed-age samples were included only if the mean age of the study population was 60 years or above or if results for the older subgroup were reported separately.

Table 1. Inclusion and exclusion criteria.

Criterion	Inclusion	Exclusion
Language	English	Non-English
Document type	Journal research article with primary outcome data	Review, guideline, consensus, editorial, conference paper, protocol or design paper
Publication period	2016 to 2025	Before 2016
Source type	Peer-reviewed journal	Book, thesis, non-indexed source
Population	Older adults, community-dwelling or clinical	Non-older, paediatric, or animal subjects
Intervention	Resistance or strength training, alone or as identifiable core	No resistance training component, or intervention not isolable
Outcome	Muscle mass, muscle strength, physical function, or sarcopenia indices	Outcomes unrelated to muscle or function
Design	Randomized or non-randomized controlled intervention	Observational, cross-sectional, or non-human study
Accessibility	Retrievable full text	Full text unavailable

Study Selection and Screening

Study selection followed a multi-stage process consistent with PRISMA 2020. Records exported from Scopus were first checked for duplication. Titles and abstracts were then screened against the eligibility criteria to remove clearly irrelevant records, after which the remaining reports were assessed in full text for final eligibility. Records were excluded at the full-text stage for specified reasons, including protocol or design status without outcomes, review or consensus format, intervention not classifiable as resistance training, observational or non-human design, and populations or outcomes outside the review scope. Where a record's eligibility was uncertain, the decision was based on the reported study design and outcome data in the source record. The complete flow of records and the reasons for exclusion are summarised in the PRISMA diagram in the Results. Screening was conducted by two independent reviewers at both the title-and-abstract and full-text stages. Inter-rater agreement was calculated using Cohen's kappa (Cohen, 1960) and yielded $\kappa = 0.83$ for title-and-abstract screening and $\kappa = 0.86$ for full-text eligibility assessment, both indicating strong concordance (Landis & Koch, 1977). Disagreements were resolved by discussion with reference to the pre-specified eligibility criteria; borderline records were retained for full-text review rather than excluded at the abstract stage to minimise premature exclusion.

Methodological Quality Appraisal

Methodological quality was appraised using design-specific critical appraisal principles rather than a single instrument applied uniformly. Each included study was first classified by design, and an appropriate appraisal tool was matched to that design. Randomized controlled trials were appraised using the Cochrane Risk of Bias 2 (RoB 2) framework (Sterne et al., 2019), while non-randomized and quasi-experimental studies were appraised using the Joanna Briggs Institute quasi-experimental principles; the Mixed Methods Appraisal Tool provides an analogous transparent, non-aggregated approach for mixed designs (Hong et al., 2018). Consistent with these tools, methodological strengths and limitations were considered narratively during synthesis rather than reduced to a single exclusionary score, and studies with greater methodological concern were interpreted with additional caution. The appraisal reported here reflects the design features described in the source records; a full per-criterion appraisal against complete full texts is recommended prior to journal submission.

Data Extraction

A structured extraction captured, for each included study, the authors, publication year, country of the study population or corresponding institution where determinable, study design, sample size and population, the resistance training intervention and its parameters (mode, frequency, and duration), the primary outcome measures, and the key findings. Where a specific attribute was not reported in the source record, it was recorded as not reported rather than inferred.

Bibliometric and Descriptive Synthesis

Descriptive and bibliometric characteristics of the included studies were summarised to contextualise the evidence base, including the annual distribution of publications, the geographic distribution of studies, and the co-occurrence of author-supplied keywords. Keyword co-occurrence was derived from the indexed keywords of the included records, after removal of generic indexing terms, to visualise the dominant conceptual clusters in the corpus.

Data Analysis and Synthesis

Given the heterogeneity of populations, interventions, and outcome measures, a narrative thematic synthesis was undertaken rather than a meta-analysis (Thomas & Harden, 2008). Findings were coded and grouped into themes reflecting the research questions, namely the effectiveness of resistance training across muscle and functional outcomes and the programme characteristics associated with those outcomes. Agreements, contradictions, and nuances across studies were identified and interpreted in light of study design and methodological quality.

Reporting and Documentation

The review was documented in accordance with the PRISMA 2020 statement, and the study selection process is reported transparently through the flow diagram and accompanying narrative (Page et al., 2021).

Results and Discussions

Study Selection

The database search identified 296 records in Scopus. As a single database was searched, no duplicate records were removed. Title and abstract screening excluded 237 records that did not meet the eligibility criteria, leaving 59 reports that were retrieved and assessed in full text. At the eligibility stage, 44 reports were excluded with reasons: 15 were study protocols or design papers without outcome data, 16 were reviews, guidelines, or consensus statements, 2 described interventions that could not be classified as resistance training, 5 were observational or non-human studies, and 6 addressed populations or outcomes outside the review scope. Fifteen controlled intervention studies met all criteria and were included in the synthesis. The full selection process is shown in Figure 1.

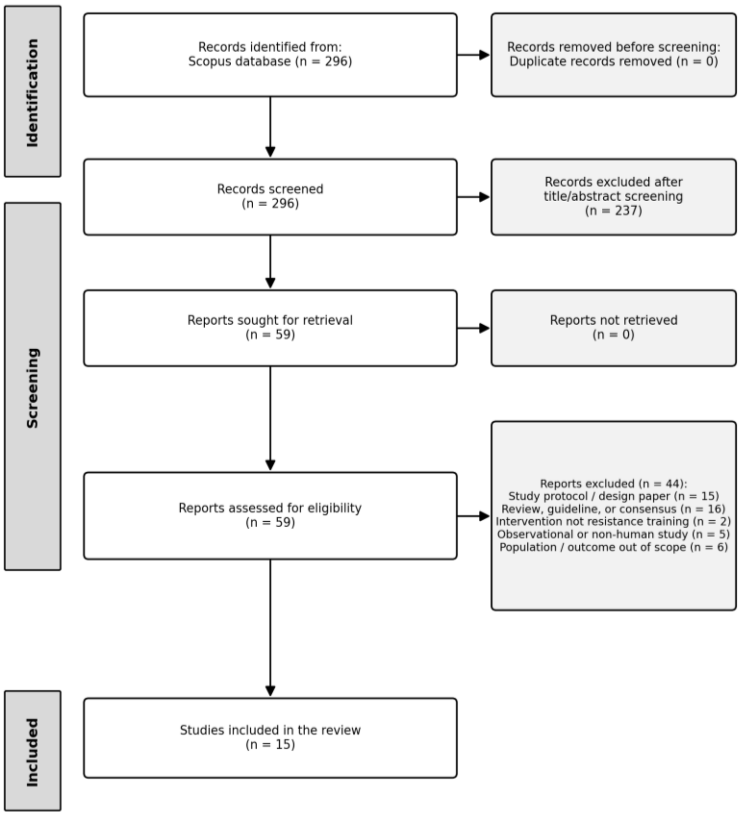

Figure 1. PRISMA 2020 flow diagram of study selection process

Descriptive Characteristics of Included Studies

The 15 included studies were published between 2017 and 2025, with a marked concentration in the most recent years: six studies appeared in 2025 and three in 2024, indicating a rapidly intensifying research interest in resistance training for sarcopenia prevention (Figure 2). Geographically, the evidence base was dominated by studies conducted in Asia, particularly Japan, China, and Thailand, with additional contributions from Southern and Eastern Europe (Figure 3). Sample sizes were generally modest, ranging from 37 to 110 participants, and populations spanned healthy community-dwelling older adults, postmenopausal and older women, institutionalised residents, and clinical groups including stroke, Alzheimer's disease, and post-bariatric surgery patients. The full characteristics of each study, including complete titles and key findings, are presented in Table 2, and a thematic and methodological classification is provided in Table 3.

Table 2. Summary of the 15 included studies.

Title	Author(s), Year	Country	Design	Key findings
Effects of aerobic and resistance training combined with fortified milk on muscle mass, muscle strength, and physical performance in older adults: A randomized controlled trial	Osuka et al., 2017	Japan	RCT	Both groups improved strength and performance; adding aerobic training to resistance training did not produce stronger muscle-mass gains than resistance training alone.
Effect of whey protein supplementation after resistance exercise on the muscle mass and physical function of healthy older women: A randomized controlled trial	Mori & Tokuda, 2018	Japan	RCT	Resistance exercise increased skeletal muscle mass index; combined exercise plus protein produced the largest gains in muscle mass, grip strength, and gait speed.
Effects of exercise improves muscle strength and fat mass in patients with high fracture risk: A randomized control trial	Chan et al., 2018	Taiwan	RCT	Two supervised exercise programmes significantly increased fat-free mass, muscle strength, and physical performance, with no significant between-group difference.
Effects of resistance training of peripheral muscles versus respiratory muscles in older adults with sarcopenia who are institutionalized: A randomized controlled trial	Cebrià I Iranzo et al., 2018	Spain	RCT	Resistance training improved knee-extension, arm-flexion, and respiratory pressures, but did not change gait speed or appendicular muscle-mass indices.
Can muscle mass be maintained with a simple resistance intervention in the older people? A cluster randomized controlled trial in Thailand	Saengrut et al., 2022	Thailand	Cluster RCT	Grip strength, skeletal muscle mass index, and walking speed improved significantly versus control, indicating prevention of muscle weakness.
Effect of Electrical Muscle Stimulation and Resistance Exercise Intervention on Physical and Brain Function in Middle-Aged and Older Women	Thapa et al., 2023	Not reported	RCT	Adding electrical muscle stimulation to resistance exercise improved muscle-mass index, gait speed, and strength, and enhanced brain activity beyond control.
The effect of unaffected side resistance training on upper limb function reconstruction and prevention of sarcopenia in stroke patients: a randomized controlled trial	Feng et al., 2024	China	RCT	Unilateral resistance training significantly improved grip strength, muscle thickness, and upper-limb function, mitigating atrophy and post-stroke sarcopenia.
Feasibility and effectiveness of a 6-month, home-based, resistance exercise delivered by a remote technological solution in healthy older adults	Ferrari et al., 2024	Italy	RCT	The technology-supported home programme was safe and feasible and improved walking parameters and maximal force, though adherence declined and body composition was unchanged.

Title	Author(s), Year	Country	Design	Key findings
Resistance Exercise Reduces Sarcopenia by Repairing Leaky Gut in Patients With Alzheimer's Disease	Qaisar et al., 2024	Not reported	Quasi-experimental	Resistance exercise improved grip strength, physical performance, and gut-barrier markers, but did not reverse sarcopenia prevalence.
A 4-Week Mobile App-Based Telerehabilitation Program vs Conventional In-Person Rehabilitation in Older Adults With Sarcopenia: Randomized Controlled Trial	Zhang et al., 2025	China	RCT	App-based tele-rehabilitation improved grip strength and function comparably to therapist-supervised in-person resistance training.
Home-Based Virtual Reality Exercise and Resistance Training for Enhanced Cardiorespiratory Fitness in Community-Dwelling Older People with Sarcopenia: A Randomized, Double-Blind Controlled Trial	Chitjamnogchai et al., 2025	Thailand	RCT	Combined virtual reality aerobic and resistance exercise significantly improved respiratory muscle strength and functional capacity relative to control.
Effect of Eight-Week Strength Training on Body Composition, Muscle Strength and Perceived Stress in Community-Dwelling Older Women	Žlibinaitė et al., 2025	Lithuania	Quasi-experimental	Short-term strength training reduced body fat and improved hamstring and grip strength, although several strength measures were unchanged.
A 12-Week Randomized Controlled Trial of Nutrition and Exercise Education with Dietary Supplementation for Sarcopenia Prevention in Korean Baby Boomers	Jang & Lee, 2025	South Korea	RCT	Grip strength improved in both education groups; the supplemented group additionally increased nutrient intake and lowered HbA1c.
Effect of short-term exercise with different programs on prevention of sarcopenia in postmenopausal women: A Quasi-Randomized Controlled Trial	Pan et al., 2025	Poland	Quasi-randomized CT	Both modalities improved mobility and knee-flexor strength; strength training also improved gait speed and grip, while Nordic-walking HIIT increased limb lean mass.
Effect of a 16-Week Exercise Program After Bariatric Surgery on Sarcopenia Parameters Based on FNIH, EWGSOP2, and EASO/ESPEN Criteria: the Results of the EXPOBAR Randomized Trial Program	Mendes et al., 2025	Portugal	RCT	The circuit exercise programme significantly improved physical function and strength and reduced fat mass, counteracting post-surgical sarcopenia parameters.

Table 3. Classification of included studies by thematic focus, design, and intervention.

Author(s), Year	Design	Thematic focus	Intervention type and delivery	Outcome domain
Osuka et al., 2017	RCT	Training plus nutrition	Aerobic and resistance training with fortified milk, supervised	Muscle mass, strength, performance
Mori & Tokuda, 2018	RCT	Training plus nutrition	Resistance exercise with whey protein, supervised	Muscle mass, strength, function
Chan et al., 2018	RCT	Comparative modality	Integrated multimodal versus lower-extremity exercise, supervised and home	Muscle mass, strength, performance
Cebrià I Iranzo et al., 2018	RCT	Resistance training core	Peripheral versus respiratory resistance training, supervised	Strength, muscle mass, gait
Saengrut et al., 2022	Cluster RCT	Resistance training core	Simple home-based resistance programme with education	Muscle mass, strength, gait

Author(s), Year	Design	Thematic focus	Intervention type and delivery	Outcome domain
Thapa et al., 2023	RCT	Technology-enabled	Resistance exercise with electrical muscle stimulation, supervised	Muscle mass, strength, brain function
Feng et al., 2024	RCT	Clinical population	Unilateral resistance training added to stroke rehabilitation	Strength, muscle thickness, function
Ferrari et al., 2024	RCT	Technology-enabled	Home resistance training via wearable and tablet	Strength, walking, body composition
Qaisar et al., 2024	Quasi-experimental	Clinical population	Resistance exercise in Alzheimer's disease	Strength, performance, biomarkers
Zhang et al., 2025	RCT	Technology-enabled	App-based versus in-person resistance rehabilitation	Strength, balance, function
Chitjamnogchai et al., 2025	RCT	Technology-enabled	Home virtual reality aerobic and resistance exercise	Respiratory strength, capacity
Žlibinaitė et al., 2025	Quasi-experimental	Resistance training core	Supervised strength training	Body composition, strength
Jang & Lee, 2025	RCT	Training plus nutrition	Online exercise and nutrition education with supplement	Strength, body composition, biomarkers
Pan et al., 2025	Quasi-randomized CT	Comparative modality	Nordic-walking HIIT versus strength training	Muscle mass, strength, mobility
Mendes et al., 2025	RCT	Clinical population	Circuit aerobic and resistance training after bariatric surgery	Strength, function, body composition

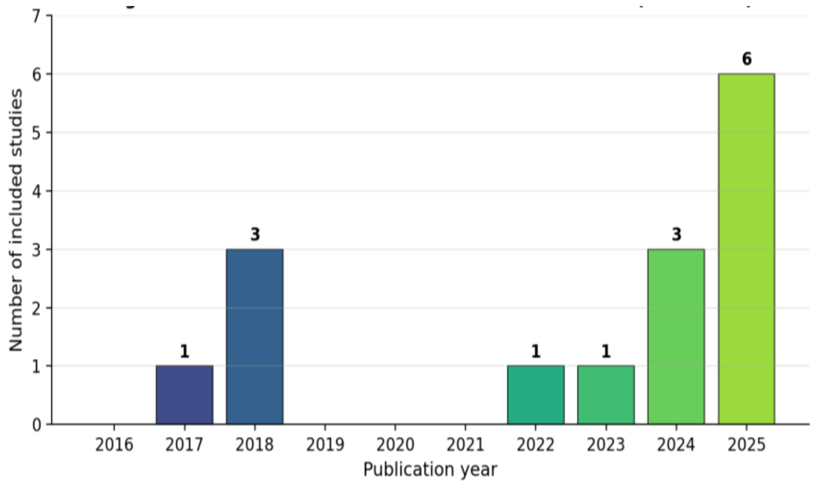

Figure 2. Annual distribution of the 15 included studies (2016-2025)

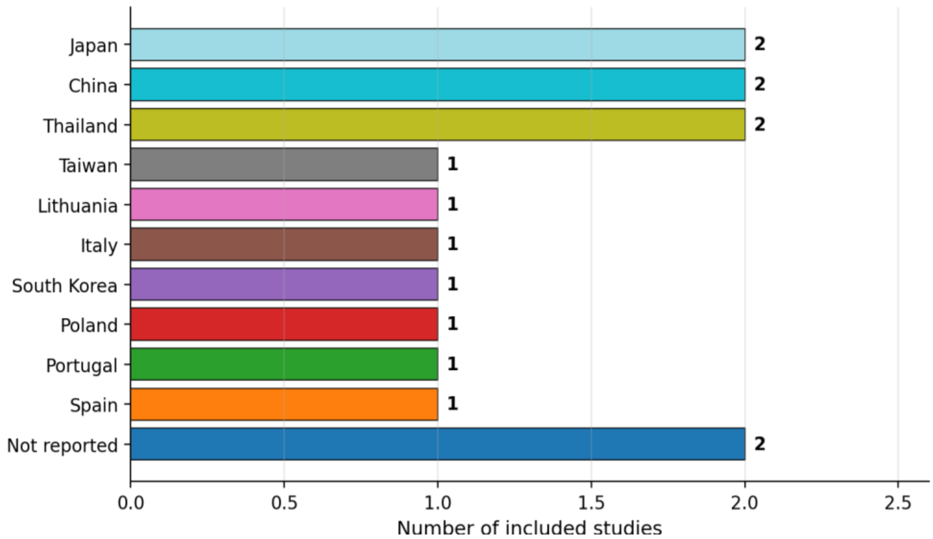

Figure 3. Geographic distribution of the included studies

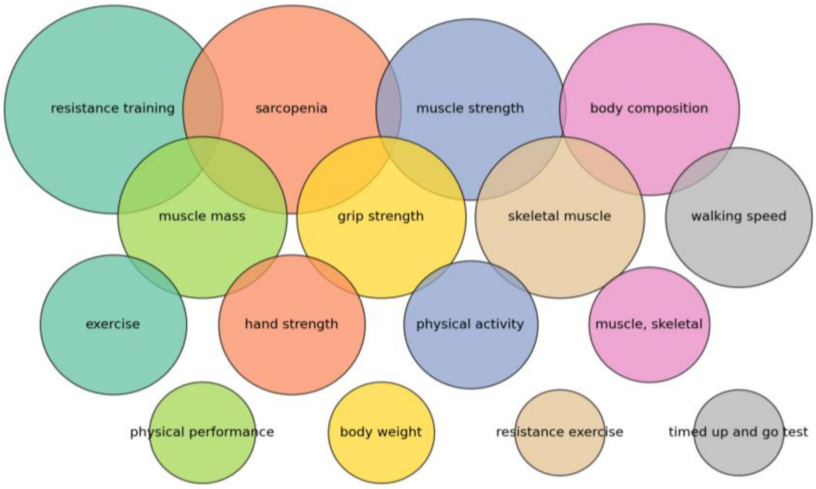

Figure 4. Author Keyword Co-occurrence Network in the Included Studies (Bubble Size Represents Frequency)

Methodological Quality

Of the 15 included studies, 12 were randomized controlled trials and 3 were non-randomized or quasi-experimental controlled studies. The randomized designs, appraised against the Risk of Bias 2 framework, generally reported random allocation and a control comparison, and several described blinding, supporting an overall judgement of low to moderate risk of bias; smaller pilot and feasibility trials warranted some additional caution owing to limited sample size. The non-randomized studies, appraised against quasi-experimental principles, carried a moderate risk of bias primarily related to non-random allocation. This appraisal is based on the design features reported in the source records, and per-criterion scoring against complete full texts is recommended before final submission. A summary is presented in Table 4.

Table 4. Methodological quality appraisal summary.

Author(s), Year	Design	Appraisal tool	Overall appraisal
Osuka et al., 2017	RCT	RoB 2	Low to moderate risk of bias
Mori & Tokuda, 2018	RCT	RoB 2	Low to moderate risk of bias
Chan et al., 2018	RCT	RoB 2	Low to moderate risk of bias
Cebrià I Iranzo et al., 2018	RCT	RoB 2	Some concerns (small sample)
Saengrut et al., 2022	Cluster RCT	RoB 2	Low to moderate risk of bias
Thapa et al., 2023	RCT	RoB 2	Some concerns (short duration)
Feng et al., 2024	RCT	RoB 2	Low to moderate risk of bias
Ferrari et al., 2024	RCT	RoB 2	Some concerns (adherence decline)
Qaisar et al., 2024	Quasi-experimental	JBI quasi-experimental	Moderate risk of bias
Zhang et al., 2025	RCT	RoB 2	Low to moderate risk of bias
Chitjamnogchai et al., 2025	RCT	RoB 2	Low to moderate risk of bias
Žlibinaitė et al., 2025	Quasi-experimental	JBI quasi-experimental	Moderate risk of bias
Jang & Lee, 2025	RCT	RoB 2	Some concerns (small sample)
Pan et al., 2025	Quasi-randomized CT	JBI quasi-experimental	Moderate risk of bias
Mendes et al., 2025	RCT	RoB 2	Some concerns (small sample)

Thematic Synthesis

Effectiveness of resistance training for sarcopenia prevention (RQ1). Across the included studies, resistance and strength training consistently improved muscle strength and physical function in older adults, supporting its role as an effective preventive stimulus. Improvements in handgrip strength were among the most reproducible outcomes, reported in community-dwelling women after eight weeks of supervised strength training (Žlibinaitė et al., 2025), in Thai older adults after a simple twelve-week home programme (Saengrut et al., 2022), and in Korean midlife adults following a combined education and exercise intervention (Jang & Lee, 2025). Lower-limb and whole-body strength gains were similarly evident, and in institutionalised older adults with sarcopenia, resistance training improved knee-extension and arm-flexion strength even where muscle-mass indices did not change (Cebrià I Iranzo et al., 2018). These convergent findings indicate that the functional benefits of resistance training are robust across diverse settings and baseline conditions.

Effects on muscle mass were more variable, revealing an important nuance. Several trials reported significant increases in skeletal muscle mass index following resistance training, particularly when training was combined with protein or fortified nutrition (Mori & Tokuda, 2018; Osuka et al., 2017), whereas others found improvements in strength and function without measurable change in appendicular muscle mass over shorter interventions (Cebrià I Iranzo et al., 2018; Ferrari et al., 2024). In specific clinical populations, resistance exercise improved strength and performance but did not fully reverse the sarcopenic phenotype, as seen in patients with Alzheimer's disease (Qaisar et al., 2024). Taken together, the evidence suggests that neuromuscular and functional adaptations often precede or exceed detectable gains in muscle mass, especially within short training windows, and that combined nutritional support may be needed to translate training into mass accrual.

Programme characteristics associated with better outcomes (RQ2). The included studies point to several programme features associated with favourable results. Effective interventions were most often delivered two to three times per week over 8 to 24 weeks, a dose consistent with supervised gains in strength and function (Mori & Tokuda, 2018; Saengrut et al., 2022; Chitjamnogchai et al., 2025). Supervision and structured progression appeared important, yet comparative trials indicated that the specific modality mattered less than consistent participation: integrated multimodal and machine-based lower-extremity programmes produced equivalent gains (Chan et al., 2018), and strength training and Nordic-walking high-intensity interval training each improved distinct outcomes in postmenopausal women (Pan et al., 2025). Adding aerobic training to resistance training did not strengthen muscle-mass outcomes beyond resistance training alone (Osuka et al., 2017), reinforcing resistance training as the principal driver of adaptation.

Delivery format emerged as a second influential characteristic, particularly in recent studies. Technology-enabled resistance training, including mobile-application tele-rehabilitation, virtual reality exercise, wearable-supported home training, and neuromuscular electrical stimulation, achieved outcomes comparable to conventional supervised training while improving accessibility (Zhang et al., 2025; Chitjamnogchai et al., 2025; Ferrari et al., 2024; Thapa et al., 2023). However, the same studies highlighted adherence as a critical moderator, with home-based programmes showing declining participation over longer periods (Ferrari et al., 2024). Combining training with protein or micronutrient supplementation was a recurring enhancer of muscle outcomes (Mori & Tokuda, 2018; Jang & Lee, 2025). Thus, the most promising configurations pair adequately dosed, progressive resistance training with strategies that sustain adherence and, where feasible, nutritional support.

Comparative and Critical Analysis

Methodologically, the corpus was dominated by randomized controlled trials, which strengthens causal inference relative to older observational literature, but the trials were frequently small, short in duration, and heterogeneous in their sarcopenia definitions and outcome batteries. Muscle strength, muscle mass, and physical performance were not consistently reported together, limiting direct comparability and precluding meta-analysis. A notable methodological evolution is the shift toward technology-enabled and remotely delivered resistance training, which broadens external validity and scalability but introduces new sources of variability in intervention fidelity and adherence. The concentration of evidence in a small number of Asian and European countries and the frequent use of clinical subgroups, including perioperative and androgen-deprivation settings where resistance training is combined with amino-acid or protein supplementation (Fujimoto et al., 2025; Kiwata et al., 2017), also constrain generalisability to broader community-dwelling older populations.

The synthesis indicates that resistance training is an effective and versatile strategy for preserving muscle strength and physical function in older adults, with more conditional effects on muscle mass. Theoretically, this pattern is consistent with the understanding that early adaptations to resistance training are substantially neural and functional, and that measurable hypertrophy typically requires sufficient training volume, progression, and nutritional substrate. The findings extend prevailing frameworks by showing that these principles hold across an increasingly diverse set of delivery formats and populations, and that the combination of training with protein supplementation is a recurring facilitator of mass accrual (Mori & Tokuda, 2018; Osuka et al., 2017; Dupont et al., 2019).

The practical implications are direct. Practitioners, clinicians, and community programme designers can prioritise progressive resistance training two to three times per week as a core preventive measure, supported where possible by adequate protein intake and by strategies that sustain adherence (Izquierdo et al., 2021; Bosaeus & Rothenberg, 2016). Technology-enabled delivery offers a credible route to scale in settings with limited rehabilitation capacity, provided that engagement is actively maintained (Zhang et al., 2025; Ferrari et al., 2024). These conclusions align with regional consensus guidance that positions resistance exercise at the centre of sarcopenia prevention and management (Zanker et al., 2023; Lim et al., 2022; Cui et al., 2023).

Situated against prior reviews and syntheses, the present findings are broadly concordant. Earlier systematic and meta-analytic work in menopausal women likewise identified non-pharmacological interventions, including resistance training, as effective for sarcopenia prevention (Tan et al., 2023), and evidence-oriented position papers have advocated the clinical implementation of muscle-strengthening programmes for older adults (Maier et al., 2023; Pereira et al., 2025). The contribution of this review is to consolidate recent controlled evidence across both conventional and technology-enabled modalities within a single PRISMA-guided framework, and to map programme characteristics to outcomes rather than treating exercise as a single undifferentiated exposure.

Several contradictions in the literature deserve emphasis. The most salient is the divergence between consistent strength and function gains and inconsistent muscle-mass gains, which likely reflects differences in training duration, intensity, nutritional co-intervention, and the sensitivity of muscle-mass measurement (Cebrià I Iranzo et al., 2018; Qaisar et al., 2024). A further tension concerns modality: while some comparisons found equivalence across exercise types (Chan et al., 2018), others reported modality-specific benefits (Pan et al., 2025), suggesting that outcome selection strongly shapes conclusions about the "best" programme. Beyond conventional training, emerging modalities are being actively trialed, including low-load resistance training with blood-flow restriction, whole-body vibration (Chen et al., 2021; Lu et al., 2022), and mind-body exercise such as Baduanjin (Wu et al., 2025), although outcome evidence for these approaches is still maturing.

At least three research gaps follow. First, standardised, consensus-based sarcopenia outcome sets are needed so that strength, mass, and function are reported together and comparably. Second, the optimal dosing of resistance training for prevention, as opposed to treatment, remains poorly defined, including intensity progression and minimum effective duration. Third, adherence mechanisms in home-based and technology-enabled programmes are under-studied despite their decisive influence on effectiveness (Ferrari et al., 2024).

This review has limitations that temper its conclusions. Reliance on a single database, Scopus, and on English-language articles may have excluded relevant evidence indexed elsewhere or published in other languages. The small number of included studies, their modest samples, and their methodological heterogeneity preclude quantitative pooling and limit the strength of causal claims. In addition, country attribution was not always reported in the source records, and the quality appraisal was informed by reported design features rather than full per-criterion scoring, which should be completed before final submission.

A concrete future research agenda emerges from these gaps. Adequately powered, longer-duration randomized trials should test standardised resistance training doses against consensus sarcopenia endpoints in representative community-dwelling older populations across more diverse regions. Trials should directly compare conventional and technology-enabled delivery while embedding validated adherence strategies, and should systematically evaluate the added value of nutritional co-interventions. In summary regarding the research questions, RQ1 is answered by evidence that resistance training reliably improves muscle strength and physical function and can improve muscle mass, particularly when combined with adequate protein; RQ2 is answered by the finding that supervised or well-supported progressive programmes performed two to three times weekly over 8 to 24 weeks, with attention to adherence and nutrition, are associated with the most favourable outcomes.

Conclusions

This systematic review of 15 controlled intervention studies indicates that resistance training is an effective strategy for preventing sarcopenia in older adults, reliably improving muscle strength and physical function, with more variable effects on muscle mass that are enhanced by adequate protein intake. In answer to the research questions, resistance training is confirmed as an effective preventive stimulus, and programmes delivered two to three times per week over 8 to 24 weeks, whether conventional or technology-enabled and supported by strategies that sustain adherence, are associated with the best outcomes. The review's core contribution is an integrated, PRISMA-guided mapping of programme characteristics to muscle and functional outcomes across diverse populations. Given the reliance on a single database, modest samples, and heterogeneous outcomes, these conclusions should be interpreted with caution, and future standardised, adequately powered trials are needed to define optimal training parameters for sarcopenia prevention.

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