

Effects of Different Exercise Training Modes on Muscle Strength, Physical Performance, and Muscle Mass in Older People with Sarcopenia in Asian Population: A Systematic Review

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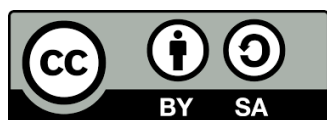
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Sarcopenia; Exercise; Resistance Training; Physical Performance; Muscle Strength; Asian Older Adults; Rehabilitation.

Abstract

Sarcopenia poses a significant threat to mobility, functional independence, and quality of life among older adults, particularly in rapidly aging Asian populations. However, evidence regarding the comparative effectiveness of different exercise modalities remains inconsistent. This systematic review evaluated the effects of various exercise training modalities on muscle strength, physical performance, and muscle mass in older Asian adults with sarcopenia. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines, systematic searches were conducted in PubMed, Scopus, Web of Science, and the Cochrane Library between March and April 2026 to identify randomized controlled trials (RCTs) published from 2010 onward. Two reviewers independently screened eligible studies, and the risk of bias was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool. Findings were synthesized narratively because of substantial clinical and methodological heterogeneity. Twelve randomized controlled trials involving 916 participants with sarcopenia, presarcopenia, or sarcopenic obesity were included. Exercise interventions generally improved physical performance, particularly walking ability, chair-stand performance, and functional mobility. Resistance training and multicomponent exercise programs frequently improved muscle strength, whereas improvements in muscle mass were less consistent. Whole-body vibration training also demonstrated potential functional benefits. Variations in diagnostic criteria, exercise protocols, nutritional supplementation, and participant characteristics limited direct comparisons among exercise modalities. Overall, exercise training appeared to improve physical function in older Asian adults with sarcopenia-related conditions; however, the available evidence was insufficient to establish the most effective exercise modality or optimal training dose. Larger, methodologically rigorous trials using standardized outcome measures and longer follow-up periods are needed to inform individualized exercise prescriptions.



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INTRODUCTION

Sarcopenia is increasingly recognized as a clinically significant age-related skeletal muscle disorder in older adults, characterized by reductions in muscle strength, muscle mass, and physical performance (Panita et al., 2015). These declines are particularly concerning because impaired muscle strength and physical performance are strongly associated with adverse health outcomes, including frailty, falls, fractures, hospitalization, increased health care costs, functional disability, loss of independence, reduced quality of life, and mortality. Muscle strength and physical performance may be more strongly associated with certain adverse outcomes than muscle mass alone (Cruz-Jentoft, 2019). Sarcopenia has become a growing public health concern, particularly in rapidly aging Asian populations. In 2016,

sarcopenia was formally recognized as a distinct clinical condition through the introduction of the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) code M62.84. This recognition facilitated greater clinical awareness and research into potential therapeutic interventions, further emphasizing the importance of sarcopenia as a major health concern among aging populations (Anker, 2016; Cruz-Jentoft, 2019; Won, 2025).

The diagnosis and classification of sarcopenia involve assessments of muscle strength, muscle mass, and physical performance. The revised European Working Group on Sarcopenia in Older People (EWGSOP2) consensus identifies low muscle strength as the primary indicator of probable sarcopenia, with reduced muscle quantity or quality confirming the diagnosis and impaired physical performance indicating severe sarcopenia (Cruz-Jentoft et al., 2019). However, diagnostic thresholds and assessment procedures may differ between Asian and Western populations because of variations in ethnicity, body size, lifestyle, adiposity, anthropometric characteristics, and cultural background (Chen, 2014). To address these population-specific differences, the Asian Working Group for Sarcopenia (AWGS) developed diagnostic criteria and assessment algorithms tailored to Asian populations (Chen, 2014; Chen et al., 2020). According to the AWGS 2019 consensus, sarcopenia is diagnosed based on low appendicular skeletal muscle mass (ASM) accompanied by either low muscle strength or impaired physical performance. The recommended assessments include appendicular skeletal muscle mass measurements, handgrip strength testing, and physical performance evaluations, such as gait speed and the five-time chair stand test (Chen et al., 2020).

The prevalence of sarcopenia varies across Asian countries because of differences in population characteristics, study settings, diagnostic methods, age distributions, and sex. Compared with Europe and North America, research on sarcopenia in Asian populations has historically been more limited, although studies have increasingly been conducted in Japan, Taiwan, China, Thailand, and South Korea. Given the rapid demographic aging and substantial population size across Asia, sarcopenia and its associated adverse health outcomes are expected to impose a considerable public health burden. Previous studies have suggested that the relationship between sarcopenia and declining physical function may differ by sex, with some evidence indicating stronger associations among men than women (Dey, 2009). Furthermore, a longitudinal study reported differences in muscle strength, muscle mass, and gait speed between older Chinese adults and Black and White adults of comparable ages, highlighting the potential influence of population-specific characteristics on sarcopenia-related outcomes (Auyeung, 2014). These findings underscore the importance of considering ethnic and demographic differences when investigating sarcopenia and developing appropriate interventions for Asian older adults.

Exercise and nutritional interventions have demonstrated benefits in the prevention and management of sarcopenia among older adults. Exercise remains a cornerstone of nonpharmacological management because physical inactivity and skeletal muscle disuse are important modifiable contributors to muscle deterioration and functional decline. Although resistance training is widely recognized for improving muscle strength, other exercise modalities may provide additional or complementary benefits. Multicomponent exercise programs combining resistance, balance, and aerobic training may be particularly beneficial for improving physical performance because sarcopenia-related functional limitations involve not only reduced muscle mass but also impaired balance, mobility, coordination, and cardiorespiratory fitness (Makizako, 2020). Whole-body vibration training has also demonstrated potential benefits for functional outcomes, including five-repetition sit-to-stand performance, 10-meter walking speed, and Timed Up and Go (TUG) test performance among older adults with sarcopenia. These findings suggest that neuromuscular stimulation may improve physical function even when the intervention does not involve conventional resistance training (Wei, 2017). Additionally, randomized controlled trials conducted by (H. Kim, 2013,

2016; H. K. Kim, 2012) supported exercise as an important intervention for sarcopenia management while indicating that improvements in muscle mass, muscle strength, and physical performance may vary according to exercise modality, nutritional co-interventions, baseline participant characteristics, and outcome measures.

Asian populations warrant particular attention in sarcopenia research because differences in diagnostic thresholds, anthropometric characteristics, and clinical profiles between Asian and Western populations may influence participant classification and responses to exercise interventions. Previous systematic reviews have generally reported beneficial effects of exercise on muscle strength and physical performance among older adults with sarcopenia. However, these reviews have frequently included heterogeneous populations, diagnostic criteria, nutritional interventions, and exercise modalities, potentially limiting the applicability of their findings to Asian populations. Although research on sarcopenia in Asia has expanded, most investigations have been concentrated in East Asian countries. The considerable diversity in ethnicity, cultural background, lifestyle, and body composition across Asia highlights the need for additional research involving populations from other Asian regions (Panita et al., 2015). Furthermore, findings from exercise intervention studies involving Asian older adults with sarcopenia remain inconsistent because of variations in exercise modalities, training protocols, intervention duration, and outcome assessment methods. Although previous studies have provided recommendations regarding exercise training approaches, no clear consensus has been established regarding the most effective exercise modality or the optimal training frequency, intensity, and duration for improving muscle strength, physical performance, and muscle mass among older Asian adults with sarcopenia (Farinatti, 2013; Harber, 2009; Liu et al., 2024; McCartney, 1995). These inconsistencies highlight the need for a systematic synthesis of evidence focusing specifically on exercise interventions in Asian populations.

Accordingly, this systematic review aimed to evaluate the effects of different exercise training modalities on muscle strength, physical performance, and muscle mass among older adults with sarcopenia in Asian populations. By focusing on Asian study populations and clinically relevant functional outcomes, the review sought to provide a population-specific synthesis of the available evidence, compare the reported effects of different exercise modalities, and identify training approaches that appeared most promising for sarcopenia management. The findings were also intended to highlight existing evidence gaps and inform future research aimed at developing individualized, evidence-based exercise prescriptions for older Asian adults with sarcopenia.

METHOD

This systematic review was conducted in accordance with the Cochrane Handbook for Systematic Reviews of Interventions (Higgins, 2024) and reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2021).

Eligibility Criteria

Eligibility criteria were defined using the PICOS framework to clearly specify inclusion and exclusion criteria for systematic reviews of health interventions.

Inclusion criteria: All included studies were RCTs with study population consisted of Asian older adults aged ≥ 60 years or as older adults according to the definition used in the RCT. Eligible participants had to be diagnosed with sarcopenia using recognized diagnostic criteria, including AWGS, EWGSOP, or study-specific operational definitions based on reduced skeletal muscle mass with low muscle strength and/or impaired physical performance. The intervention had to include a structured exercise training program, such as resistance training, elastic resistance training, concurrent aerobic-resistance training, whole-body vibration training, and multicomponent exercise programs combining resistance, balance,

flexibility, gait, or aerobic components. The trials had to include control or any comparator. Studies were required to report at least one clinically relevant outcome related to muscle strength, physical performance, or muscle mass/body composition.

Exclusion criteria: Reported results were outside outcome interest, studies without sufficient or no extractable outcome data, not full text, enrolled non-sarcopenic older adults without a clearly extractable sarcopenia subgroup, included mixed ethnic populations without a separately extractable Asian subgroup, no continuous exercise intervention, exercise intervention's total duration was less than 8 weeks with less than 60 minutes of exercise per week, were designed as case reports; observational studies; reviews; conference abstracts; editorials, and animal-based studies; which fall outside the scope of this review.

Search Strategy and Study Selection

A comprehensive literature search was conducted in PubMed, Scopus, Web of Science, and the Cochrane Library from March 1, 2026 to April 1, 2026. Included studies are the latest reports since 2010. No restrictions were applied to exercise modality. Reference lists of included studies and relevant reviews were also manually screened to identify additional eligible studies. The search was structured around five main concepts: sarcopenia, older adults, exercise training, muscle strength or physical performance outcomes, and randomized controlled trials. No restriction was applied to exercise modality during the search because this review aimed to compare different training modes, including resistance-based, power, concurrent, whole-body vibration, home-based, and multicomponent exercise programs. Search terms included keyword combinations of “sarcopenia”, “pre-sarcopenia”, “sarcopenic obesity”, “older adults”, “elderly”, “exercise”, “resistance training”, “elastic band”, “whole-body vibration”, “multicomponent exercise”, “physical performance”, “muscle strength”, “muscle mass”, and “randomized controlled trial”, “combined using Boolean operators (“AND” and “OR”).

All identified records were imported into a reference management software program, and duplicate records were removed before screening. Two reviewers independently screened titles and abstracts against the eligibility criteria. Full texts of potentially relevant studies were then assessed independently by the same reviewers. Disagreements at any stage were resolved through discussion and consensus. The study selection process was summarized using a PRISMA flow diagram.

Data Extraction

Extracted data included study characteristics, participant characteristics, intervention details, comparator group, and outcomes relevant to the objective of this review. For each study, the following information was extracted: author, publication year, country, sample size, sex distribution, age, sarcopenia diagnostic criteria, exercise training mode, intervention protocol (containing exercise modalities, frequency, intensity, time, duration, type), control or comparator group, and reported outcomes relevant to review objective. The main outcomes of interest were muscle strength (including handgrip strength, knee extension strength or leg extension strength, lower- or upper-body strength); physical performance (including gait speed or walking speed, Timed Up-and-Go test, chair stand test or chair-rise test or sit-to-stand test, single leg stance, cardiorespiratory fitness, other functional mobility measures); and body composition (skeletal muscle mass, skeletal muscle mass index, appendicular muscle mass, appendicular lean mass, leg muscle mass, fat-free mass, total skeletal mass, body fat percentage, total fat mass, and trunk fat mass).

Risk of Bias

Risk of bias was assessed using the revised Cochrane Risk of Bias tool for randomized trials (RoB 2), which is designed to evaluate bias in a specific estimate of intervention effect from randomized trials. Five RoB 2 domains were evaluated: bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing

outcome data, bias in measurement of the outcome, and bias in selection of the reported result (Sterne, 2019; Sterne et al., 2019). Each domain was judged as “low risk of bias,” “some concerns,” or “high risk of bias.”

Handling of Heterogeneity

Clinical heterogeneity was evaluated by comparing participant phenotype and eligibility across studies, including sarcopenia, pre-sarcopenia, and sarcopenic obesity, as well as differences in age, sex distribution, and setting. Methodological heterogeneity was assessed through differences in diagnostic criteria, study design features, intervention delivery, comparator conditions, and follow-up duration. Outcome heterogeneity was assessed by examining variation in the definitions, parameters, and time points used to measure muscle strength, physical performance, and muscle mass/body composition. Methodological heterogeneity was considered through study design features and risk-of-bias judgments.

Given this heterogeneity, a structured narrative synthesis was undertaken. The included studies were grouped according to exercise training mode, and findings were synthesized across three main outcome domains: muscle strength, physical performance, and muscle mass/body composition. Patterns of benefit and consistency of findings were interpreted together to identify which exercise modalities appeared most consistent.

RESULTS AND DISCUSSION

Study Characteristics

The 12 included randomized studies comprised a total of 916 older Asian adults with sarcopenia, pre-sarcopenia, or sarcopenic obesity. The trials were conducted in Asian settings, including Japan, Taiwan, Hong Kong, and Iran, with sample sizes ranging from 15 to 155 participants. The included populations were generally community-dwelling older adults aged approximately 60–80 years. Overall, the evidence base was female-predominant because multiple trials enrolled women only, particularly the Japanese exercise–nutrition studies and the Taiwanese sarcopenic obesity studies.

The diagnostic criteria varied across studies but all were based on recognized sarcopenia criteria incorporating low skeletal muscle mass, reduced muscle strength, and/or impaired physical performance. Several studies used EWGSOP-based criteria, while others used AWGS-based criteria. The rest of the trials used study-specific criteria based on handgrip strength, walking speed, skeletal muscle mass index, or BMI-related criteria. This variation reflects the evolving diagnostic framework of sarcopenia in Asian populations.

Heterogenous exercise modalities as interventions were observed. This supports a narrative comparison by training mode rather than a single pooled interpretation. Exercise modalities included are concurrent aerobic-resistance training, weighted-vest low-load power training, elastic band resistance training, whole-body vibration, home-based exercise, multicomponent exercise combining resistance, balance, gait exercise, flexibility, and aerobic elements, and exercise combined with nutritional supplementation. All, except one study, incorporated resistance training in their exercise program. Intervention duration ranged from short programs of approximately 6–8 weeks to longer protocols of 12 weeks to 6 months. Taken together, the included studies provided a clinically diverse but coherent evidence base for evaluating how different exercise training modes influence muscle strength, physical performance, and muscle mass in older Asian adults with sarcopenia.

Based on the PRISMA flow diagram (Figure 1), 1,020 records were identified from databases; after removal of 276 duplicates and 12 records for other reasons, 744 records were screened. A total of 86 reports were assessed using our eligibility criteria, and 12 randomized studies were included in the final review.

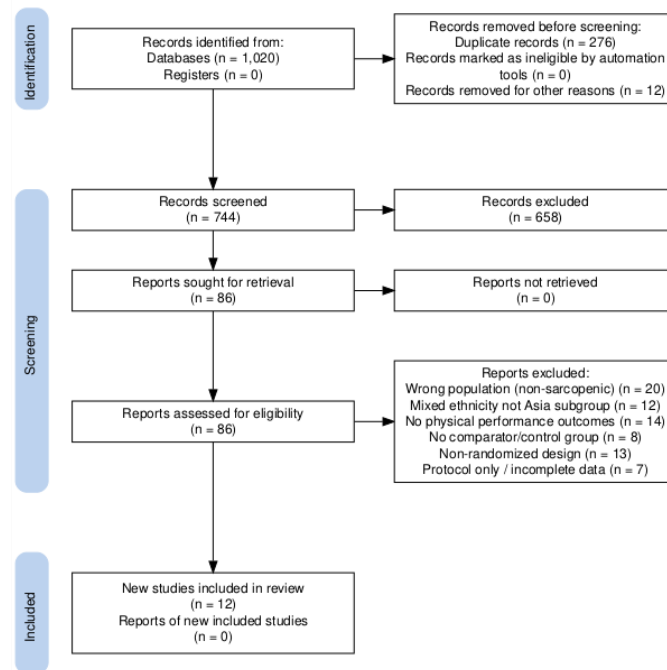


Figure 1. PRISMA flow diagram of study selection for the systematic review of exercise training modes on muscle strength and physical performance in older adults with sarcopenia in Asian populations

Table 1. Characteristics of included randomized controlled trials evaluating exercise interventions in older adults with sarcopenia in Asian populations

Author	Year	Country	Sample / Diagnosis Criteria	Male/ Female	Age	Intervention Frequency, Intensity, Time, Type (FITT)	Outcome	Control Group
Bagheri et al.	2020	Iran	30 HGS < 26–30 kg, four meters GS < 0.8 m/s, and a BMI at least 2 SD below the average young population	30/0	63.8 ± 3.6 (R+E group); 61.1 ± 3.3 (E+R group); 65 ± 3.9 (control group)	3x/week (separated by at least 48h) For 8 weeks Concurrent training: -Resistance training with resistance machine: • 40%-75% of 1-RM, 8-16 rep • Leg extension, leg curl, bench press, lat pulldown, lateral raise, abdominal crunch -Endurance training with fixed speed bike: • 55% of maximum HR for 15 min in the first week to 70% of maximum HR for 30 min in the last week; *Cool down : 10 min using low-intensity exercise on cycle ergometer (4 min), slow walking (4 min), light lower limb stretches with special focus on quadriceps, hamstrings, calves and erector spinae	• CT improved weight, body composition, muscle mass, function, and aerobic fitness • In the RT group, changes in weight were significantly correlated with changes in BMI ($r = 0.85$, $P < 0.01$), FLST ($r = -0.63$, $P < 0.05$) and lower body strength ($r = 0.81$, $P < 0.01$). • Increase in: VO2max, upper and lower body muscular strength, SMM; and decrease in BFP after CT	Non-exercise
Hamaguchi et al	2017	Japan	15 EWGSOP criteria. SMI < 6.12 kg/m ²	0/15	60.4 ± 2.7 (training group); 60.6 ± 2.3 (control group)	Low repetition and light-load progressive power training with weighted vest: • 2x/week • for each exercise: 8 sets of 3 reps with 15 sec. rest between each set for 60 min • for 6 weeks	• Within-group changes in pelvis Bone Mass Density (BMD) and KES were significantly greater in the EG than the CG ($p = 0.029$ and 0.030 for	Non-exercise

						Squats, front lunges, side lunges, calf raises, and toe raises	pelvis BMD and KES, respectively). Improvements in pelvis BMD (1.6%) and KES (15.5%) after low-repetition, light-load power training	
Kim et al	2012	Japan	155	0/155	0/ 79.5 ± 2.9 (exercise + amino acid supplementation group) 79.0 ± 2.9 (exercise group) 79.2 ± 2.8 (AAS group) 78.7 ± 2.8 (health education group)	Resistance training + Balance and gait training: 2x/week - Up to 8 reps for each movement, 60min/session (5 min warm-up, 30 min strengthening exercise, 20 min balance and gait training, 5 min cool down) - For 3 months - Type : -Ankle weight exercise : seated knee flexion and extension and standing knee flexion and extensions -Resistance band exercise : double-arm pull downs and biceps curls; leg extension and hip flexion; -Balance and gait training : standing on one leg, multidirectional weight shifts, tandem stand, and tandem walk; raising the toes (dorsiflexion) during the forward swing of the leg, kicking off the floor with the ball of the foot, walking with directional changes, and gait pattern variations Amino acid supplementation: 3g supplement 2x/day (6g/day), everyday - For 3 months - Powdered amino acid supplement	- Significant increase in leg muscle mass and KES, and leg muscle mass and usual walking speed in E + AAS - Improvements of 2.4% in leg muscle mass, 2.0% in AMM, and 4.3% in leg strength, and walking speed in EG; suggesting that exercise is effective in the improvement of muscle mass and functional fitness	Non-exercise
Kim et al	2013	Japan	128	0/128	0/ 79.6 ± 4.2 (exercise group) 81.1 ± 3.7 (exercise + tea catechin) 80.2 ± 5.6 (health education group) 80.0 ± 4.0 (tea catechin group)	Resistance training + Balance and gait training: 2x/week - Up to 8-10 reps for each type of exercise, 2 sets 60m/session (5-min stretching warm-up of the neck, shoulders, lower back, hips, knees and ankles, 30 min of strengthening exercises, 20 min of balance and gait training, followed by a 5-min cool-down) - For 3 months - Type : -Resistance band exercise for upper body and ankle weight exercise for lower body (focused on hip extensors and adductors, knee flexors and extensors, and ankle dorsi and plantar flexors) -Balance and gait training: one-leg stands, tandem stand and tandem walking Tea catechin supplementation: 1 bottle/day, everyday - For 3 months 350mL of tea fortified with 540mg catechin	- The combination of Ex + TC supplementation had a beneficial effect on muscle mass and physical function measured by walking ability. - The Ex + TC group showed a significant effect (OR 3.61, 95% CI 1.05–13.66) for changes in the combined variables of leg muscle mass and usual walking speed compared with the health education group	Non-exercise
Kim et al	2016	Japan	139	0/139	0/	Resistance training + Aerobic training: 2x/week	The combination of exercise and nutrition effectively	Non-exercise

						SMM<5.67 kg/m²; HGS<17.0 kg; walking speed <10m/s + BFP ≥32% 81.4 ± 4.3 (exercise group) 80.9 ± 4.2 (exercise + nutrition group) 81.2 ± 4.9 (nutrition group) 81.1 ± 5.1 (health education group) • 60 min/session • For 3 months • Type : -Chair exercise : toe raises, heel raises, knee lifts, and knee extensions were performed while seated on a chair. Then performed 1-3 sets of 10 hip flexions, lateral leg raises, squats, standing knee lifts, gluteal kicks, and repetitions of other exercises while standing upright behind the chair and holding the back of it. -Resistance band : leg extensions, hip flexions, and more; double-arm pulldowns, bicep curls, and others -Hydraulic exercise machine : seated row, leg press, abduction, leg extension, and abdominal crunch machines, beginning with 1-3 set of 10 repetitions. -Aerobic training : pedalled on stationary bicycle for 12 min. Starting at 40 watts, then gradually increased. Nutrition: • 1x/day, everyday • For 3 months • Type: - Amino acid supplementation : 1 packet/day. 3g essential amino acid and 20µg vitamin D - Tea catechin : 1 bottle/day. 350mL of 540mg catechin-fortified tea	improved body fat, blood components, and physical function in sarcopenic obese elderly women. • No significant changes in SMI and HGS. • Ex+N intervention significantly decreased total BF, increase stride, KES, and walking speed • Trunk fat was significantly reduced in EG compared to CG.	
Liao et al	2017	Taiwan	46	0/46	66.39 ± 4.49 (training group) 68.42 ± 5.86 (control group) EWGSOP	Resistance elastic training: • 3x/week • 3 sets of 10 reps or 35-40 minutes (with 10 min warm-up, 5 min cool down) • For 12 weeks • Using TheraBand : seated chest press, seated row, seated shoulder press; concentric-eccentric hip circumduction, leg press, leg curl.	• ERT exerted benefits on the body composition (muscle mass), muscle quality, and physical function (functional mobility) in patients with sarcopenic obesity. • Body composition outcomes in EG : increase in FFM and Leg Lean Mass; decrease in total fat and BFP. • Physical capacity outcomes: increase in functional mobility tasks, strength gain, muscle quality, and GS, faster in TUGT, performed more repetition in TCR, balanced longer in SLS	Non-exercise
Liao et al	2018	Taiwan	56	0/56	66.67 ± 4.54 (training group) 68.32 ± 6.05 (control group) EWGSOP + BFP >30%	Resistance elastic training: • 3x/week • 3 sets of 10 reps for 40 minutes (with 10 min warm-up, 5 min cool down) • For 12 weeks • Using TheraBand : seated chest press, seated row, and seated shoulder press; knee extension, knee flexion, hip flexion, and hip extension	• ERT exerted a significant beneficial effect on muscle mass, muscle quality, and physical function in older women with sarcopenic obesity. • Muscle mass outcome: Improvement in appendicular lean mass, AMM, and TSM. • Physical capacity and function outcomes: improvement in mobility, and global	Non-exercise

							physical capacity, muscle quality. EG had improvements in TUGT, TCR test, FFR time, SLS test, and GS than CG.	
Makizako et al	2020	Japan	72 AWGS	21/51	75.0± 6.9	Resistance training, balance, flexibility, and aerobic exercises : • 1x/week • up to 10 reps/movement; 60 min/session (brief warm up, 25-30 min resistance training, 20-25 min balance and 6 min aerobic exercises, 5 min cool-down) • 12 weeks • Type: - Resistance exercise with TheraBand : 1) knee extension (quadriceps), 2) hip flexion (knee raises) (psoas major and iliacus), 3) hip internal rotation (gluteus medius and minimus), 4) elbow flexion and shoulder abduction (trapezius and rhomboid), 5) elbow flexion and trunk rotation (pectoralis major and oblique abdominis), 6) hip extension (gluteus maximus), 7) knee flexion (hamstrings), 8) hip abduction (gluteus medius), and 9) squat (quadriceps, gluteus maximus, and hamstrings) - Balance and gait training : tandem stand, heel-up stand, one-leg stand, weight shifts, and stepping (anterior-posterior and lateral) - Aerobic exercise : anterior-posterior or lateral stepping repetitions	• No significant muscle mass change in exercise group • Physical function improved in the EG: Improvement in maximum gait speed, performance on the TUGT	Educational
Maruya et al	2016	Japan	52 AWGS	23/29	69.2 ± 5.6 (exercise group) 68.5 ± 6.2 (control group)	Home exercise resistance and balance training: • Everyday • 3 sets/day (Single leg standing for 1 min, 6 reps/set of squats for 6 sec then return to standing position, heel raise 20 reps/set). Aerobic : Walk rhythmically for 20-30 min/day • For 6 months • Lower limb training (locomotion-training) with weightlifting apparatus : squats, single leg standing and heel raise, walking	• A 6-month home exercise program improved physical function in community-dwelling individuals with pre-sarcopenia or sarcopenia. • The intervention improved HGS, SLS (60.5 s to 77.2 s) and KES (1.38 Nm/kg to 1.69 Nm/kg) in EG • Decrease in BMI and maximum walking speed in CG. • No significant changes in sarcopenia and pre-sarcopenia status	Non-exercise
Moghadam et al	2020	Hong Kong	30 HGS <26-30kg, walking speed < 0.8 m/s over 4 meters, and a SMI < 2SD below the average young adult population	30/0	63.8 ± 3.6 (R+E group) 64.1 ± 3.3 (E+R group) 65 ± 3.9 (control group)	• 3x/week (separated by at least 48h) • For 8 weeks • Concurrent training: E+R group exercise ET first, followed by RT. R+E group exercise RT first, followed by ET. Resistance training using resistance machines: • 2 sets of 16-18 reps at 40% of 1RM in the first week, progressed to 3 sets of 8-10 reps at 75% 1RM in the eighth week. • Leg extension, leg curl, bench press, lat pulldown,	• Weight, SMM, lower and upper body power, maximal oxygen consumption (VO2max), Pax7, and Myf5 significantly improved in EG. • BF significantly decreased following E+R and R+E compared to CG. • Improvement in SMM, lower and upper body power was significantly greater in	Non-exercise

						lateral raise, and abdominal crunch	the E+R group than the R+E group	
						Endurance training with fixed speed cycle ergometer: • 55% of maximum heart rate for 15 minutes in the first week and progressed to 70% of maximum heart rate for 30 minutes in the eighth week.		
Wei et al	2017	Hong Kong	80 SMI: Male <8.87kg/m ² and Female <6.42kg/m ²	24/56	78 ± 4 (Low Frequency group) 75 ± 6 (Medium Frequency group) 74 ± 5 (High Frequency group) 76 ± 6 (control group)	Whole-body Vibration : • 3x/week • 14,400 vertical vibrations divided into 4 sets for all training groups (3,600 vibration cycles each). Peak-to-peak amplitude was 4mm for all training groups. Rest time for one set: 5 min • For 12 weeks • WBV machine platform: a) low-frequency with long exercise time (20Hz x 720s), b) medium frequency with medium exercise time (40Hz x 360s), c) high-frequency with short exercise time (60Hz x 240s)	• With the total number of vibrations controlled, the combination of 40Hz and 360s of WBV has the best outcome on physical performance of people with sarcopenia. • Between-group differences in percentage change from baseline were significant between medium-frequency group and CG on all outcome variables after 12-week WBV training (Five-repetition TCR test: 10.46 ± 2.28 (–16.12%), p= 0.008; 10-meter walking test: 1.05 ± 0.16 (11.18%), p = 0.04; TUGT: 11.32 ± 1.72 (–15.08%), p = 0.001).	Non-WBV
Zhu et al	2019	Hong Kong	113 AWGS	26/87	74.5 ± 7.1 (exercise group) 74.8 ± 6.9 (Combined-exercise program + nutrition supplement) 72.2 ± 6.6 (control group)	Resistance and aerobic training : • 1x/week • 40% of the estimated 1RM, 6-8 reps , 6 sets. (5–10 min warm-up and cool-down routine, 20–30 min chair-based resistance exercises using Thera-Bands, and 20-min aerobic exercises) • For 12 weeks • Resistance training using TheraBand : Upper body muscle group (chest, back, biceps, triceps); lower body (knee extension/flexion, heel raises, side leg lifts). Nutrition : • 2 sachet / day • For 12 weeks • 1 sachet : 54.1 g powder contains 231 calories, 8.61 g protein, 1.21 g β-hydroxy β-methylbutyrate, 130 IU vitamin D and 0.29 g omega-3 fatty acid	• Significant improvement in leg extension strength, and five-TCR occurred in Ex+Nutrition group and EG that persisted to 24 weeks. • Physical Activity Scale for the Elderly improved in both intervention groups that persisted until 24 weeks only in the combined group. • Lower limb muscle and ASM increased significantly in the combined group but the increase was not sustained to 24 weeks.	Non-exercise

Follistatin (FLST); bone mineral density (BMD); resistance training (RT); aerobic training (AT), endurance training (ET), elastic band resistance training (ERT) ; upper limb (UL), lower limb (LL), exercise group (EG); control group (CG); whole body vibration (WBV); ET followed by RT (E+R); RT followed by ET (R+E); concurrent training (CT); Body Mass Index (BMI); skeletal muscle mass (SMM); skeletal mass index (SMI); body fat percentage (BFP); body fat (BF); fat free mas (FFM); knee extensor strength (KES); handgrip strength (HGS); gait speed (GS); timed up-and-go test (TUGT); timed chair-rise (TCR); single-leg-stance (SLS); standard deviation (SD); appendicular muscle mass (AMM); appendicular skeletal muscle (ASM); skeletal muscle index (SMI); total skeletal mass (TSM); functional

forward reach (FFR); Exercise with amino acid supplementation (E+AAS); Exercise with tea catechin (E+TC); paired box 7 (Pax7); myogenic factor 5 (Myf5)

Across the 12 included randomized studies, exercise-based interventions generally produced favorable effects on at least one clinically relevant outcome related to muscle strength, physical performance, or muscle-related body composition in older Asian adults with sarcopenia, pre-sarcopenia, or sarcopenic obesity. The most consistent improvements were observed in physical performance outcomes, particularly walking ability, Timed Up-and-Go, chair stand performance. Improvements in muscle strength were also frequently reported, especially for knee extension strength and lower-limb power, whereas changes in muscle mass and body composition were more variable across exercise modes.

Clinical and Methodological Heterogeneity of Included Studies

Substantial heterogeneity was observed across the included trials. Participant phenotype varied from sarcopenia to pre-sarcopenia and sarcopenic obesity, and several studies were restricted to women, whereas others enrolled mixed-sex or male-only populations. Diagnostic definitions also differed across trials, with some using AWGS criteria, others EWGSOP criteria, and others employing study-specific operational definitions based on combinations of low muscle mass, muscle strength, gait speed, or BMI-related thresholds. Intervention modalities, protocols and evaluation time were also diverse. Outcome measures were similarly heterogeneous, ranging from gait speed, Timed Up-and-Go, chair stand, and leg extension strength to appendicular skeletal muscle mass, lean mass, body fat indices, and others.

Quality Score

Across the 12 included randomized studies, the overall methodological quality was moderate. The overall judgment showed that 33.3% of studies were classified as low risk of bias, while 66.7% were classified as having some concerns. No study was judged as high risk of bias overall. The most frequent concerns arose from missing outcome data and selection of the reported result, whereas the highest proportion of low-risk judgments was observed in the domains of randomization process and measurement of the outcome. This suggests that most trials used acceptable randomization procedures and objective outcome measures such as knee extension strength, gait speed, Timed Up-and-Go, chair stand, and other physical performance tests.

Table 2. Risk of bias assessment of included randomized controlled trials using the Cochrane Risk of Bias 2 (RoB 2) tool

Study	D1	D2	D3	D4	D5	Overall
Bagheri, 2020	Low	Low	Low	Low	Low	Low
Hamaguchi, 2017	Some concerns	Some concerns	Some concerns	Some concerns	Low	Some concerns
Liao, 2017	Low	Low	Some concerns	Low	Some concerns	Some concerns
Liao, 2018	Low	Low	Some concerns	Low	Some concerns	Some concerns
Wei, 2017	Low	Some concerns	Some concerns	Low	Low	Some concerns
Kim, 2012	Low	Low	Low	Low	Low	Low
Kim, 2013	Low	Some concerns	Some concerns	Low	Some concerns	Some concerns
Kim, 2016	Some concerns	Some concerns	Low	Some concerns	Some concerns	Some concerns
Moghadam, 2020	Low	Low	Low	Low	Low	Low
Makizako, 2020	Low	Some concerns	High	Some concerns	Low	Low

Maruya, 2016	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns
Zhu, 2018	Some concerns	Some concerns	Some concerns	Low	Low	Some concerns

Code	Domain
D1	Bias arising from the randomization process
D2	Bias due to deviations from intended interventions
D3	Bias due to missing outcome data
D4	Bias in measurement of the outcome
D5	Bias in selection of the reported result

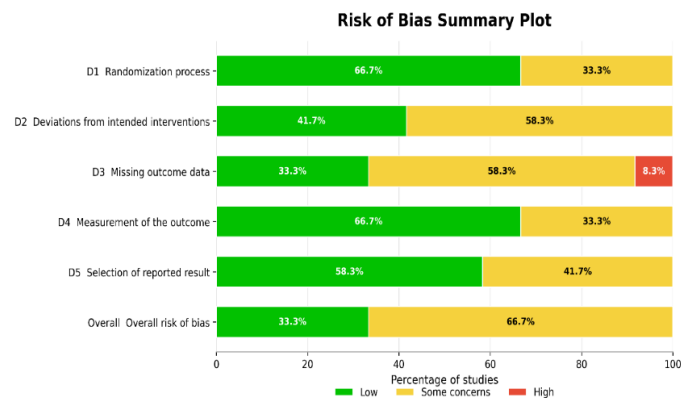


Figure 1. Percentage Distribution of Risk of Bias Across Assessment Domains in the Included Studies

Outcome

Effects on Muscle Strength

Effects on muscle strength were observed in eight out of twelve studies. Hand grip strength and leg extension strength were most commonly reported, but predominantly leg or knee extension strength was more frequently mentioned as a significant improvement effect after exercise intervention (Bagheri, 2020; Hamaguchi, 2017; H. Kim, 2016; H. K. Kim, 2012; Liao, 2017; Makizako, 2020; Maruya, 2016; Moghadam, 2020).

The studies that reported an effect on muscle strength all used resistance-based training as their modalities, whether it's resistance-based exercise alone, resistance-based exercise combined with balance and gait training, or resistance-based exercise combined with aerobic or endurance training (including concurrent training). Most of the exercises that produced muscle strength benefits are combinations of resistance-based training and aerobic training, with different modalities used such as elastic band, resistance machine or apparatus, weighted vest, or ankle weights; while aerobic training exercises included walking and working on a fixed speed bicycle.

Three studies that included nutritional supplementation along with exercise intervention reported strength improvements in their combined exercise and nutrition intervention group. These studies included resistance training combined with aerobic training or balance and gait training with the supplementation of amino acid only, amino acid and tea catechin, or nutrition supplementation consisting protein, vitamin D, and omega 3 fatty acid. (Kim et al., 2012, Kim et al., 2016, Zhu et al., 2018)

Effects on Physical Performance

Physical performance was the most consistently improved outcome domain. It was observed in almost every of the studies included (eleven studies). Improvements in walking speed or gait speed, Timed Up-and-Go test, chair stand test were the most frequently reported significant outcome. (Bagheri et al., 2020, Liao et al., 2017, Liao et al., 2018, Kim et al., 2012, Kim et al., 2013, Kim et al., 2016, Makizako et al., 2020, Maruya et al., 2016, Moghadam et

al., 2020, Wei et al., 2017, Zhu et al., 2017) VO₂max outcome was included in only two studies, both incorporated concurrent training as their exercise intervention and both reported a significant improvement in VO₂max. (Bagheri et al., 2020, Moghadam et al., 2020)

The studies that reported effects on physical performance used multicomponent training and whole-body vibration as their modalities. The exercise mode that produced the most physical performance benefits are multicomponent exercises that incorporated resistance-based training, aerobic training and balance and gait training, with different modalities used such as elastic band, resistance machine or apparatus, weighted vest, or ankle weights; while aerobic training exercises included walking, stepping, and working on a fixed speed bicycle.

Four studies that included nutritional supplementation along with exercise intervention reported physical performance improvements in their combined exercise and nutrition intervention group. These studies included resistance training combined with aerobic training or balance and gait training with the supplementation of amino acid only, tea catechin only, amino acid and tea catechin, or nutrition supplementation consisting protein, vitamin D, and omega 3 fatty acid. (Kim et al., 2012, Kim et al., 2013, Kim et al., 2016, Zhu et al., 2018)

Effects on Muscle Mass and Body Composition

Muscle mass and body composition responses were less uniform than physical performance outcomes. These outcomes were reported in eight out of twelve included studies. Most frequently reported body composition outcomes were improvements in skeletal muscle mass, appendicular muscle mass, leg muscle mass, and body fat. (Bagheri et al., 2020, Liao et al., 2017, Liao et al., 2018, Kim et al., 2012, Kim et al., 2013, Kim et al., 2016, Moghadam et al., 2020, Zhu et al., 2017)

The studies that reported effects on muscle mass and body composition all used resistance-based training as their modalities. Most of the exercises that produced body composition benefits are multicomponent exercises that incorporated resistance-based training and aerobic or endurance training, with different modalities used such as elastic band, resistance machine or apparatus, weighted vest, or ankle weights; while aerobic training exercises included walking, stepping, and working on a fixed speed bicycle.

Four studies that included nutritional supplementation along with exercise intervention reported physical performance improvements in their combined exercise and nutrition intervention group. The exercise intervention regime and supplementation intervention are the same as ones that resulted in physical performance effects. (Kim et al., 2012, Kim et al., 2013, Kim et al., 2016, Zhu et al., 2018)

Exercise Training Mode Comparison

When interpreted by exercise mode, the included trials suggest modality-specific patterns of benefit rather than a definitive hierarchy of efficacy. Resistance-based interventions showed the most consistent pattern of benefit across both muscle strength, physical performance, and muscle mass outcomes. Resistance training with elastic band was particularly favorable in sarcopenic subjects, especially ones with obesity (Liao et al., 2017; Liao et al., 2018). Although used in almost every included study, not every study that incorporate only resistance-based training could result in all strength, performance, and mass outcomes. Exercises using resistance machine and elastic band were frequently associated with improvements in muscle strength, especially lower-limb strength, whereas muscle mass was reported more with exercises using elastic band.

Multicomponent exercise, including concurrent training, produced the broadest physiological response, more consistently resulting in all strength, performance, and mass outcomes. Aerobic capacity (VO₂max), regulatory markers (follistatin, myostatin, Pax7), Physical Activity Scale for the Elderly, blood components were also reported as results of this exercise modality, mainly after concurrent training (Bagheri et al., 2020, Moghadam et al., 2020). A combination of resistance-based training and aerobic training was predominantly

reported as exercise modality that resulted in all three outcomes. (Bagheri et al., 2020, Kim et al., 2016, Moghadam et al., 2020, Zhu et al., 2018). The rest of the modalities that resulted in all three outcomes were resistance training alone and resistance training combined with balance and gait training (Liao et al., 2017, Kim et al., 2012). Aerobic training used in these studies were walking, stepping, and pedaling on a fixed speed bicycle.

Whole-body vibration appeared most relevant for physical performance outcomes. Whole-body vibration improved sit-to-stand, walking speed, and Timed Up-and-Go test without clear muscle mass gain, with the medium frequency (40 Hz for 360s) showing the best physical performance response. (Wei et al., 2017)

Exercise with nutritional supplementation showed clinically relevant but less uniform effects across strength, performance and muscle mass outcomes. Out of four studies that included nutritional supplementation, three of them resulted an increase in lower limb strength (Kim et al., 2012, Kim et al., 2016, Zhu et al., 2018), while all of them reported increase in muscle mass and physical performance (Kim et al., 2012, Kim et al., 2013, Kim et al., 2016, Zhu et al., 2018).

Based on Table 1, the outcomes extracted from the included studies were organized into three main domains: muscle strength, physical performance, and muscle mass/body composition; aligned with the aim of this systematic review, which was to evaluate the effects of different exercise training modes on muscle strength and physical performance in older Asian adults with sarcopenia. It is also consistent with current sarcopenia criteria, particularly AWGS 2019, which emphasizes muscle strength and physical performance as key clinical elements in the identification and assessment of sarcopenia in Asian populations (Chen et al., 2020). Across the 12 included randomized studies, exercise-based interventions generally produced favorable effects on clinically relevant outcomes, especially physical performance and lower-limb muscle strength.

Muscle mass and body composition had mixed result. The less shown muscle mass outcome was due to absence of muscle mass measurement as study's objective or the study did not find any significant result regarding exercise and muscle mass. Elastic resistance training appeared beneficial for muscle-related body composition in sarcopenic obesity. Liao et al. 2017 reported significant between-group improvement in fat-free mass and muscle quality, and leg lean mass change was significantly correlated with gait speed change ($r = 0.36$, $p < 0.05$) (Liao et al., 2017). Liao et al. 2018 also reported significant improvements in total skeletal muscle mass, appendicular lean mass, appendicular muscle index, muscle quality, and physical capacity after elastic band resistance training (Liao et al., 2018). Liao et al. reported that RT improves the body composition in obese elderly individuals with improvement in strength, physical function, and mobility. Loss of muscle mass, particularly in the lower limb muscle groups, leads to further mobility difficulty and functional limitations in elderly individuals. This may be explained by the association between muscle loss with aging and the high risk of mobility limitations and that RT is advantageous for muscle mass and strength gain in elderly individuals. RT has been reported to be beneficial for physical function by increasing muscle protein synthesis and muscle strength in elderly individuals with sarcopenia or in those with obesity. Their findings of an increase in both leg lean mass and improved physical mobility levels after RT may be explained by the association between low muscle mass and the high risk of mobility limitations. (Liao et al. 2017).

Other than resistance training alone, most studies that resulted in muscle mass change consisted of combination of resistance training and aerobic training. Concurrent training was associated with improvement in skeletal muscle mass and body composition. Bagheri et al. reported increased skeletal muscle mass and reduced body fat percentage after concurrent aerobic-resistance training (Bagheri et al., 2020). Moghadam et al. similarly reported increases in skeletal muscle mass and reductions in body fat percentage after concurrent training, with

greater improvement in skeletal muscle mass when endurance training preceded resistance training (Moghadam et al., 2020).

Strength-related outcomes included handgrip strength, knee extension strength, upper-body strength, lower-body strength, lower- and upper-body power, and muscle quality. As shown in Table 1 and 2, knee or leg extension strength was frequently assessed across intervention modes, including low-repetition light-load weighted vest power training, home-based exercise which included resistance training and balance and gait training, exercise combined with amino acid supplementation, elastic resistance training, and exercise with resistance machine. Handgrip strength improvement was only reported in home exercise which incorporated resistance training and balance and gait training (Maruya, 2016). Other strength outcomes were reported in concurrent training studies, which assessed upper- and lower-body muscular strength or power. Hamaguchi et al. reported that low-repetition, light-load power training significantly improved knee extensor strength compared with control, with a 15.5% increase after six weeks of training; however, no significant change was observed in skeletal muscle index, suggesting that early strength improvement may occur through neuromuscular adaptation rather than measurable hypertrophy (Hamaguchi, 2017). However, Moghadam et al. reported that improvements in skeletal muscle mass and power-related outcomes were greater when endurance training was performed before resistance training. This may be because the parallel result found in muscle mass, indicating that changes in strength and power go along with changes in skeletal muscle mass. (Moghadam et al., 2020)

Physical performance was the most frequently reported outcome. Across twelve studies multicomponent exercises and whole-body training showed clear functional benefits. Wei et al. found that the medium-frequency protocol, 40 Hz for 360 seconds, produced significant improvements compared with control in five-repetition sit-to-stand, 10-meter walking test, and Timed Up-and-Go after 12 weeks. The reported changes were -16.12% for five-repetition sit-to-stand, +11.18% for 10-meter walking speed, and -15.08% for Timed Up-and-Go (Wei et al., 2017). Makizako et al. reported significant group-by-time interactions for chair stand performance ($p = 0.02$) and Timed Up-and-Go ($p = 0.01$) after a 12-week intervention combining resistance, balance, flexibility, and aerobic training. No significant interaction effect was observed for muscle cross-sectional area or muscle volume, indicating that functional gains may occur even without significant measurable increases in muscle mass (Makizako et al., 2020).

Some studies showed significant changes in strength or physical performance without significant changes in muscle mass of body composition. These findings suggest that exercise may improve task performance through neuromuscular adaptation, repeated task-specific practice, balance control, improved coordination, and repeated practice of functional movements, even when measurable hypertrophy is limited (Makizako et al., 2020, Hamaguchi et al., 2017, Wei et al., 2017, Kim et al., 2012). The early definition by Janssen et al. solely relied on low muscle mass for identification (Janssen, 2004). However, compared to low muscle mass alone, muscle weakness plays a more significant role in adverse health outcomes for older individuals (Weng et al., 2019). Hence, contemporary approaches advocate for a more comprehensive evaluation, incorporating assessments of both muscle strength and muscle function alongside low muscle mass for a definitive diagnosis of sarcopenia. This interpretation is consistent with prior study which reported that exercise in older adults with sarcopenia significantly improved knee-extension strength, Timed Up-and-Go, appendicular muscle mass, and leg muscle mass, but also emphasized that training effects were inconsistent because of heterogeneity in exercise mode, duration, and intensity (Vlietstra et al., 2018). Their discussion also noted that a 12-week intervention was sufficient for functional changes, but may be too short to induce hypertrophic or body-composition changes. Our review supports this concept in an Asian-specific evidence base: several studies demonstrated improvements in strength or

performance despite limited or absent changes in muscle mass, particularly in short-duration or functionally oriented interventions.

Resistance-based exercise has been well-recommended for producing a consistent strength, physical performance, and muscle mass outcomes. Elastic resistance training in Taiwanese older women with sarcopenic obesity improved muscle mass, muscle quality, body composition, gait speed, Timed Up-and-Go, timed chair rise, and single-leg stance outcomes (Liao et al., 2017; Liao et al., 2018). This is clinically relevant because elastic resistance training is relatively low-cost, portable, and adaptable to community-based or home-based programs. Liao et al. also revealed that RT had a significantly more favorable outcome for muscle mass and physical capacity (i.e., distance of Functional Forward Reach Task, time for TUG and SLS, effort of TCR, GS), compared with the CG. (Liao et al. 2018) Based on the fact that type-II myofiber atrophy is associated with aging and that RT predominantly benefits type-II myofiber hypertrophy, resistance-type exercises help elderly individuals with sarcopenia or obesity to counterforce muscle-attenuated physical difficulties through increasing muscle synthesis and muscle strength. The Cochrane review by Liu and Latham also reported that progressive resistance training improves physical functioning and strength in older adults, including performance of simple functional activities (Liu and Latham, 2009). In present review, resistance-based training that produces positive physical effects is not limited to conventional machine-based resistance training but were also observed with other modes, such as elastic bands, ankle weights, weighted vests, and home-based resistance movements. This suggests that the principle of progressive muscular training, rather than the equipment itself, is likely the key therapeutic component.

Power-oriented and neuromuscularly oriented interventions proven to be effective in improving physical performance in older adults with sarcopenia. Hamaguchi et al. reported that low-repetition, light-load power training using a weighted vest significantly improved knee extensor strength and pelvis bone mineral density (BMD) without requiring high-load resistance exercise. This finding suggests that low-load, velocity-oriented exercise may be useful for older adults who are unable to perform high-load training (Hamaguchi et al., 2017). Low-repetition, light-load power training would allow individuals to have sufficient rest intervals required for maximizing power output and restoring mechanosensitivity of bone cells, thereby positively affecting BMD. Knee extensor strength was increased, however there is no significant change in SMI (Hakkinen, 2001).

Similarly, whole-body vibration improved physical performance. These results expand the practical options for sarcopenia management beyond the conventional resistance training, particularly for frailer older adults or settings where supervised gym-based training is less feasible. The positive findings of whole-body vibration training on physical performance in their participants were consistent with some previous studies. (Iwamoto, 2012). It is also suggested from the study that adequate exposure time is essential for vibration training to be effective. Bellomo et al. reported increase in muscle strength following focal vibration on leg muscle. Focal vibration is an effective method to activate the proprioceptive sensory system. It consists in the excitation of the afferences coming from the neuromuscular spindle. This causes the activation of a large number of alpha-motor neurons, leading to the recruitment of muscle fibers, previously inactive, to contribute to muscle contraction (Iwamoto et al. 2012). The adaptive responses to vibration of the neuromuscular apparatus therefore cause an increase in contractility force of stimulated muscles and in the adjacent ones. (Bellomo, 2013)

Concurrent aerobic-resistance training produced the broadest physiological response. Bagheri et al. reported improvements in body composition, skeletal muscle mass, upper- and lower-body muscular strength, VO_2max , and body fat percentage after concurrent training, while Moghadam et al. reported increases in skeletal muscle mass, upper- and lower-body power, VO_2max , Pax7, and Myf5, with reduced body fat percentage after concurrent training

(Bagheri et al., 2020; Moghadam et al., 2020). Two studies that observed concurrent training effects showed that VO₂max improved after intervention. VO₂max is maximum rate of oxygen consumption that decreases with aging. Decreased VO₂ is related to decline in use an availability of oxygen. This marker clinically indicated the level of aerobic capacity that is strongly associated with cardiovascular risk factors and quality of life. Aerobic or endurance training had proven to be beneficial for improving VO₂max and cardiovascular function. This implicated that concurrent training showed to increase not only strength, functional performance and muscle mass, but also cardiovascular health. These findings suggest that concurrent training may be particularly useful when sarcopenia coexists with loss of aerobic capacity, excess adiposity, or metabolic risk. However, the limited number of concurrent training studies and the small sample sizes mean that the optimal sequence of aerobic and resistance components needs further investigation. (Bagheri et al., 2020, Moghadam et al., 2020)

Across all twelve studies, combination of resistance and aerobic training showed the most consistent result for all three outcomes. This may be explained by the benefits of resistance training on increasing muscle synthesis and muscle strength, while aerobic training is type of exercise that increases the cross-sectional area of muscle fibers, mitochondrial volume and enzyme activity; although less likely to increase muscle hypertrophy. Combinations of aerobic and resistance exercise can further improve muscle strength and muscle function and is important to prevent and treat sarcopenia. (Panita et al., 2015)

The findings regarding exercise combined with nutritional supplementation were mixed. Kim et al. found that exercise plus amino acid supplementation improved the combined outcome of leg muscle mass, knee extension strength, and usual walking speed, while Kim et al. later reported that exercise plus tea catechin supplementation improved leg muscle mass and usual walking speed (Kim et al., 2012; Kim et al., 2013). However, Kim et al. 2016 reported improvements in body fat, knee extension strength, and walking speed in intervention group for sarcopenic obese elderly women, but no significant changes in skeletal muscle index or grip strength. Zhu et al. also found that exercise alone and exercise-nutrition improved leg extension strength and five-chair stand test; and lower-limb muscle mass increased only in the exercise-nutrition group, without sustained effect at 24 weeks (Zhu et al., 2018). These mixed findings are aligned with Beaudart et al., who concluded that physical exercise has a beneficial impact on muscle mass, strength, or physical performance in older adults, whereas the effect of nutritional supplementation was reported only in a limited number of studies (Beaudart et al., 2017). Therefore, the present review supports the interpretation that nutrition may be an adjunct to exercise, but it should not be interpreted as definitely superior to exercise alone for physical performance in Asian older adults with sarcopenia.

An important novel contribution of this review is the population-specific synthesis. Previous systematic reviews have evaluated exercise in older adults with sarcopenia for non-specific population, but Asian populations require distinct interpretation because diagnostic criteria, body size, adiposity, lifestyle exposure, and physical performance thresholds differ from Western populations. AWGS 2019 defines low muscle strength as handgrip strength <28 kg for men and <18 kg for women, and low physical performance as 6-meter walk <1.0 m/s, SPPB ≤9, or five-time chair stand ≥12 seconds (Chen et al., 2020). The included Asian trials used a range of AWGS, EWGSOP, and study-specific index values, which reflects real-world evolution in sarcopenia diagnosis but also limits comparability. Nonetheless, focusing on Asian populations makes the findings more applicable to regional clinical practice and supports the need for Asian-specific exercise prescription research.

The review also highlights a clinically meaningful distinction between “morphological response” and “functional response.” Muscle mass is biologically important, but strength and performance appear to be more sensitive to exercise-induced change over short to moderate

intervention periods and load. It has also been stated in multiple studies that physical function and strength was more important in increasing mobility and quality of life and decrease mortality risk rather than muscle mass. (Kim et al., 2016, Newman et al., 2006)

This finding is relevant for clinical trials and rehabilitation practice because outcomes such as gait speed, Timed Up-and-Go, chair stand, and knee extension strength may capture early and meaningful benefit even if skeletal muscle mass change is not observed. This is also consistent with AWGS 2019, which introduced “possible sarcopenia” based on either low muscle strength or low physical performance to enable earlier lifestyle intervention in community settings (Chen et al., 2020).

Limitation

This study has some limitations. Substantial clinical and methodological heterogeneity was identified across the included trials in terms of participant phenotype, diagnostic criteria, exercise modality, exercise regime, co-interventions, comparator condition and outcome measurements. Bearing such heterogeneity, a formal meta-analysis was not performed. This heterogeneity limited direct comparability and was the main reason for choosing a structured narrative synthesis.

Another limitation relevant to interpretation is that modality-specific conclusions were drawn from heterogeneous trials rather than direct head-to-head pooled comparisons. Although the included studies suggest that certain exercise modes may be particularly promising for specific domains, the present review does not permit a definitive ranking of exercise modalities. As such, statements regarding which exercise mode appeared more favorable should be understood as comparative patterns observed across studies rather than definitive evidence of superiority of one modality over another. This is particularly relevant for physical performance outcomes, which were assessed using different instruments such as gait speed, Timed Up-and-Go, chair stand, and five-repetition sit-to-stand tests, each reflecting overlapping but non-identical functional constructs.

RCTs included are all comparing exercise intervention to non-exercise intervention, thus more RCT and meta-analysis comparing different types of exercise with more uniform diagnostic criteria, subject phenotype, and outcome measure in sarcopenic Asian population should be conducted.

CONCLUSION

The findings of this systematic review supported exercise as a key therapeutic strategy for managing sarcopenia in older Asian adults, particularly for improving physical performance and lower-limb muscle strength. Across the 12 included randomized studies, the most consistent improvements were observed in functional outcomes, including gait speed, Timed Up and Go (TUG) test performance, chair-stand performance, and sit-to-stand ability. Several studies also reported improvements in muscle strength, particularly knee extension strength and lower-limb muscle power, although increases in muscle mass were less consistent. Among the exercise modalities examined, combined resistance and aerobic training demonstrated relatively consistent benefits across muscle strength, physical performance, and muscle mass outcomes. Exercise interventions combined with nutritional supplementation also showed potential benefits across these outcomes; however, the available evidence was insufficient to establish the superiority of nutritional supplementation alone over exercise-based interventions.

A key finding of this review was that improvements in physical performance were more consistent than increases in muscle mass. Several studies reported significant improvements in functional performance or muscle strength without corresponding significant increases in muscle mass. These findings suggested that the benefits of exercise among older Asian adults with sarcopenia might extend beyond muscle hypertrophy and involve neuromuscular

adaptations, improved motor coordination, enhanced balance, increased muscle power, and task-specific functional adaptations. Consequently, improvements in physical function may occur independently of substantial changes in muscle mass, highlighting the importance of evaluating multiple outcome domains when assessing the effectiveness of exercise interventions for sarcopenia management.

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