Evidence on physical activity and frailty/sarcopenia prevention for people aged 65+ years

Prepared for the Guideline Development Group for the
WHO Guidelines on physical activity and sedentary behaviour for children and adolescents, adults and older adults

WHO Collaborating Centre for
Physical Activity, Nutrition and Obesity

AUTHORS AND FUNDING

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EXECUTIVE SUMMARY

Background

This report is intended to inform the WHO Guideline Development Group (GDG) update of the WHO Global Recommendations on Physical Activity for Health.

Aims

We aimed to investigate evidence on the association between physical activity and prevention of frailty and sarcopenia in older people (aged 65+ years). Questions were: (i) what is the association between physical activity and sarcopenia/frailty prevention?; (ii) is there a dose response association (volume, duration, frequency, intensity) between physical activity and the prevention of frailty and sarcopenia?; (iii) does the association vary by type or domain of physical activity?

Methods

A search for existing systematic reviews was conducted in PubMed for reviews published from 2008 up to November 2019. Reviews were screened according to the following criteria: (i) population: adults aged 65 years and older; (ii) exposure: greater volume, duration, frequency, or intensity of physical activity; (iii) comparison: no physical activity or lesser volume, duration, frequency, or intensity of physical activity; (iv) outcomes: frailty, sarcopenia and related measures (e.g., strength, physical performance and muscle mass); (v) study design: systematic review and meta-analysis. We used GRADE to assess the evidence.

Results

The search yielded 191 records. As none of the 34 potentially eligible reviews met our eligibility criteria we identified relevant individual studies included in these reviews. We identified 8 trials and 1 observational study from 21 reviews and included these in this report. Seven trials compared physical activity with a control intervention.

- Physical activity may prevent frailty. The quality of the evidence was low, suggesting limited confidence in the results. Only one trial evaluated prevention of frailty.
- We are uncertain whether physical activity prevents sarcopenia. The quality of the evidence was very low. Only one observational study evaluated prevention of sarcopenia.
- Physical activity interventions may improve performance on frailty-related outcomes (n=4). The overall quality of the evidence was low.
- Physical activity interventions may improve performance on sarcopenia-related outcomes (n=2). The overall quality of the evidence was low.
- Clear statements about the optimal type of exercise or dose response associations are not possible at this stage. Studies that detected impacts on relevant outcomes involved resistance training, balance and functional exercises, endurance training, combinations of these and overall physical activity.

Conclusions

Physical activity may play a role in the prevention of sarcopenia and frailty and in improving related outcomes but the quality of evidence is very low/low, so there is uncertainty regarding these conclusions. These results should be interpreted with caution due to the lack of eligible systematic reviews and the possible omission of recent individual studies due to the search used.

BACKGROUND

Frailty and sarcopenia are common age-related conditions associated with increased adverse outcomes, such as falls, mobility disorders, the need for long-term care, and death.*(1, 2)* There is ongoing debate about how to best define frailty and sarcopenia.

Frailty is characterised by a decline in functioning across multiple physiological systems that increases susceptibility to stressors.*(2)* The concept of frailty generally involves a multidimensional condition that is part of the normal ageing process.*(3)* Frailty is dynamic, which means that the severity of frailty can change in either direction over time.*(2, 3)* Rockwood et al. defined410 frailty as a 'multidimensional syndrome of loss of reserves (energy, physical ability, cognition, health) that gives rise to vulnerability'.*(4)* Fried and colleagues developed the phenotype model to classify frailty, which consists of five physical components: unintentional weight loss, low grip strength, self-reported exhaustion, slow walking speed, and low physical activity.*(5)* Frailty can be lessened by exercise-based interventions.*(6)*

Sarcopenia is a musculoskeletal disorder affecting older people that involves accelerated loss of muscle mass and function.*(1)* Sarcopenia was defined by the European Working Group on Sarcopenia in Older People (EWGSOP) as (1) low muscle mass, (2) low muscle strength and/or (3) low physical performance.*(7)* The recent updated consensus statement from the European Working Group on Sarcopenia in Older People (EWGSOP2) defines sarcopenia as a “muscle disease (muscle failure) rooted in adverse muscle changes that accrue across a lifetime”, notes that sarcopenia is common among adults of older age but can also occur earlier in life and focuses on “low muscle strength as a key characteristic of sarcopenia, uses detection of low muscle quantity and quality to confirm the sarcopenia diagnosis, and identifies poor physical performance as indicative of severe sarcopenia”.*(8)* Sarcopenia is a clinical biomarker to identify people at increased risk of mobility disability.*(9)* The Sarcopenia Definitions and Outcomes Consortium (SDCO) identified grip strength as an important discriminator of mobility disability and a predictor of health-related outcomes.*(9)* Given the importance of strength and function in predicting adverse outcomes in older adults and the role of factors outside the muscle in strength and function (particularly neurological input), others have questioned the wisdom of the focus on muscle structure that is implied by sarcopenia and suggest use of terms such as muscle strength and motor impairment.*(10)* It is well known that strength and function in older adults can be improved with exercise.

Physical activity has also been identified as a potential preventive strategy to slow the development of both frailty and sarcopenia. The information provided in this report is intended to inform the WHO Guideline Development Group (GDG) update the WHO Global Recommendations on Physical Activity for Health.*(11)*

METHODS

The Guideline Development Group decided on the scope of the guideline and PICO (Population, Intervention, Comparison, Outcome) question.

Guiding Questions

What is the association between **physical activity** and **frailty/sarcopenia**?
Is there a dose response association (volume, duration, frequency, intensity)?
Does the association vary by type or domain of physical activity?

Eligible studies

Studies were selected according to the criteria below. Additional details on the eligibility criteria are provided in Appendix 1.
Population: Adults aged 65 years and older.
Exposure: Greater volume, duration, frequency, or intensity of physical activity.
Comparison: No physical activity or lesser volume, duration, frequency, or intensity of physical activity.
Outcomes: Frailty and/or sarcopenia or related measures (e.g., strength, physical performance and muscle mass);
Study design: Systematic review and meta-analysis.

Search and selection strategy

A search for existing systematic reviews was conducted in PubMed for reviews published from 2008 up to November 2019 (Appendix 2).

Two reviewers independently screened titles and abstracts of potential systematic reviews. Where there was uncertainty about the eligibility of a study, the full text was retrieved. Two independent reviewers read full-texts and assessed eligibility criteria using an electronic screening form. Disagreements regarding the eligibility of studies were resolved through discussion and, when necessary, with the help of a third reviewer.

Since we did not find any eligible systematic reviews, we identified reviews that included potentially eligible studies and screened all included studies against our questions. We included individual studies (instead of reviews).

One reviewer extracted information into standardised forms and a second reviewer checked all data. We extracted all outcome measures relevant to sarcopenia and frailty reported by the studies that were included. We selected the most commonly reported outcomes across the included studies to provide an overview of the evidence.

Physical activity classification

We used the Prevention of Falls Network Europe (ProFANE) taxonomy to classify the physical activity and exercise programmes in the included studies (Appendix 3).*(12)* The programmes were classified as primarily involving the following exercise categories: (i) gait, balance, coordination and functional task training (referred to as 'balance and functional exercises' for simplicity); (ii) strength/resistance training (including power training, using resistance so referred to as 'resistance exercises'); (iii) flexibility; (iv) three-dimensional (3D) exercise (with Tai Chi or dance subcategories); (iv) general physical activity (walking programmes); (v) endurance; (vi) overall physical activity; (vii) other.

Grading the body of evidence

Using the GRADE framework, we examined the quality of primary research and assessed the overall quality of evidence in terms of presence and extent of five factors: risk of bias, inconsistency, imprecision, indirectness and publication bias. Details on the criteria used to apply the GRADE approach are provided in Appendix 4. We also undertook random-effects meta-analyses to summarise the effects of physical activity where there was more than one study.

INCLUDED EVIDENCE

Overview

The initial search for systematic reviews and meta-analyses did not identify enough evidence to answer the review question. We screened the full text of 34 reviews and did not find any eligible reviews (Figure 1). The main reasons for exclusion were reviews including younger participants (n=10), not including frailty/sarcopenia related outcomes (n=10), participants with frailty/sarcopenia at baseline (management instead of prevention, n=6), including multimodal interventions (e.g., combined physical activity and nutrition intervention, n=5). The reasons for exclusion for each review at full text assessment are reported in Appendix 5.

Amongst the 34 reviews which had their full text screened, 21 reviews included potentially eligible studies and their full texts were identified and assessed by two reviewers. We used the same eligibility criteria, but no restriction was applied for publication year of individual studies. We found nine studies*(3, 13-20)* investigating the association between physical activity and the primary prevention of frailty/sarcopenia and included them in the report.

Publication dates ranged from 1996 to 2019 (median=2013). There were eight randomised controlled trials (RCT) and one longitudinal study. Studies were undertaken in seven countries including United States, Brazil and Korea. Details of all included studies are summarised in the Table 1.

Participant characteristics

In the trials reporting age, the mean age of participants ranged from 69 years to 79 years. Five included studies that recruited both men and women,*(3, 13, 18, 19)* and four studies recruited only women.*(14-17)* All participants from the included studies were recruited from the community. Three studies included pre-frail participants at baseline.*(15, 17, 18)* The other studies did not have pre-frailty and pre-sarcopenia status as an inclusion criteria.

Exposure

The duration of the interventions in the included trials ranged from short (i.e., 10 weeks) to as long as 78 weeks, and the median duration was 21 weeks (mean=31 weeks). The intervention dose ranged from 1 to 5 sessions per week with the sessions ranging from 40 to 60 min. Within the included trials, seven studies compared physical activity with a control intervention, *(3, 13-16, 18, 19)* and three compared different doses or types of physical activity.*(3, 14, 17)*

The included studies investigated a wide range of physical activity and exercise modalities. Following the ProFANE taxonomy, three studies primarily investigated resistance training, two studies investigated multiple categories exercise, two investigated balance/function training, one investigated endurance (walking) and one investigated Tai Chi.

Outcomes

Frailty was an outcome for one of the included studies.*(18)* In this study frailty was measured using the following five Fried criteria: (1) unintentional weight loss, (2) exhaustion, (3) low physical activity, (4) slow walking speed, and (5) poor grip strength. Participants were classified as frail if they fulfilled three or more criteria. Sarcopenia was an outcome in one of the included studies*(20)* and was defined according to the European Working Group on Sarcopenia in Older People (EWGSOP). Participants who had (1) low muscle mass, (2) low muscle strength and/or (3) low physical performance were classified as having sarcopenia.

A range of frailty and sarcopenia related outcomes, i.e. individual measures that make up the definitions of frailty and sarcopenia, were also reported in the included studies. The most commonly reported outcomes were measures of (i) muscle strength, such as grip strength and isokinetic dynamometer; (ii) measures of physical function, such as Timed up and Go test (TUG) and sit-to-stand/chair rise test; and (iii) measures of muscle mass, such as dual-energy X-ray absorptiometry (DXA). We performed an overall assessment of the evidence according to frailty status outcome (Table 3), sarcopenia status outcome (Table 4) as well as two additional assessments according to frailty-related outcomes (Table 5) and sarcopenia-related outcomes (Table 6). The forest plots from the meta-analyses summarising the effects of physical activity on these outcomes are shown as Figures 2, 3 and 4.

Methodological quality of trials

We assessed the methodological quality of the RCTs using the PEDro scale.*(21)* The overall quality of included studies was moderate (median 5, range 3 to 6). The PEDro total scores are reported for all relevant studies in tables 1 to 6 and the scores for each item are reported in Appendix 6. We used an adapted version of the Quality in Prognosis Studies (QUIPS) tool to assess risk of bias of one observational study, which was rated as "low risk of bias".

Overview of included studies

Studies investigating physical activity vs control interventions

A total of seven RCTs*(3, 13-16, 18, 19)* investigated physical activity interventions compared with a control group. Overall the sample size for the trials was small (median: 53, range: 32 to 187) and the median follow-up length was 38 weeks. We identified two studies *(18, 20)* with frailty or sarcopenia outcomes (Table 2).

The only study to measure frailty was by Serra-Prat et al.*(18)* and involved a RCT to investigate the effect of a physical activity program in pre-frail community-dwelling older people. A total of 133 participants were considered for analysis and the mean age in the study samples was 78 years (53% women). The intervention was classified as involving multiple types of exercise (endurance, balance and function). The dose of the intervention was four times per week with sessions of 20 to 45 minutes. The outcome was prevalence of frailty, defined as the presence of three or more Fried criteria. This study found that the likelihood of frailty after intervention was significantly lower in the intervention group (adjusted OR 0.19, 95% CI 0.04 to 0.95).

The only study to measure sarcopenia was by Yu et al.*(20)* and involved an observational study of 4000 community-dwelling people aged 65 years and older (mean age = 73 years; 50% women). Sarcopenia status was defined as low muscle mass, low muscle strength and/or low physical activity. The results concerning physical activity as exposure factor showed a small protective association between overall physical activity and incidence of sarcopenia (OR 0.995, 95% CI 0.991 to 0.999).

Physical activity may prevent frailty but we are uncertain of the impact on sarcopenia. As there was only one study for each of these outcomes (an RCT for frailty and an observational study for sarcopenia), the quality of the body of evidence was assessed as low for frailty and very low for sarcopenia, suggesting limited confidence in the results (Appendix 8 and 9).

We also assessed the evidence for frailty-related outcome measures. A total of four RCTs*(3, 15, 16, 19)* investigated the impact of physical activity on frailty-related outcomes. Overall, 326 participants were considered for analysis and the mean age was 73 years (range 70-76 years). The interventions were classified into resistance training (3/4 studies) as well as Tai Chi and balance/function (1/4 studies). Control group varied from no intervention, usual care, and low-level exercise. The frailty-related outcomes included (i) muscle strength, measured with leg press with 1 RM method, isokinetic dynamometer and grip strength; (ii) physical function, measured with chair rise, 6-m, 10-m and 12-m walk, Timed Up and Go test, and SPPB; (iii) muscle mass measured with dual-energy X-ray absorptiometry (DXA). Overall, the results suggested that physical activity interventions may improve frailty-related outcome measures in older adults, such as strength, physical function and muscle mass (Table 5). The quality of the evidence was low, suggesting limited confidence in the results (Appendix 10).

Two RCTs*(13, 14)* investigated the evidence for sarcopenia-related outcomes. A total of 204 participants were analysed, and the mean age was 73 years. Goodpaster et al.*(13)* examined the effect of a supervised training classified into endurance (walking) on sarcopenia-related outcomes compared to no intervention. The dose of the intervention varied from 2 to 5 sessions per week, with session duration ranging from 40 to 60 minutes. The sarcopenia-related outcomes involved (i) muscle strength measured with Kin-Com dynamometer, and (ii) muscle mass measured with axial Computed Tomography (CT) scan. Kemmler et al.*(14)* investigated the effect of two different doses of a supervised, group-based exercise program on sarcopenia-related outcome compared to control group. The intervention was classified as involving multiple types of exercise (endurance, balance and function, and resistance), and the control group involved education and relaxation training. The dose of the intervention varied between 1-4 sessions per week with sessions of 60 minutes supplemented by 20 minutes home training session. The sarcopenia-related outcome included muscle mass assessed by dual-energy X-ray absorptiometry (DXA) technique. Overall, they suggested that that physical activity interventions may improve sarcopenia-related outcome measures in older adults (Table 5). The quality of the evidence was low, suggesting limited confidence in the results (Appendix 11).

Forest plots and pooled effect sizes from meta-analyses are shown in Figures 2, 3 and 4. These suggest a positive impact of the interventions on outcomes related to frailty and sarcopenia.

Appendix 12 provides the abstracts for all included studies.

Studies investigating physical activity vs control interventions by physical activity type

Studies that detected impacts on relevant outcomes typically involved resistance training, balance and functional exercises, endurance training, combinations of these and overall physical activity. For example, interventions classified into a combination of endurance, balance and function, as well as overall physical activity had positive effect on sarcopenia/frailty outcomes in two studies.*(18, 20)*

Regarding frailty and sarcopenia related outcomes, interventions classified into resistance training, endurance training, Tai Chi, balance/function training and a combination of these had a positive impact on muscle strength, muscle mass and physical function.

Studies investigating different doses of physical activity interventions

Only two studies compared different doses of physical activity on frailty and sarcopenia related outcomes.*(14, 17)* However, only one study*(14)* reported effect estimates between groups. Therefore, it was not possible to fully investigate a dose-response relationship.

The comparisons were: high frequency (>2 sessions per week) versus low frequency (<2 sessions per week),*(14)* and moderate intensity versus vigorous intensity.*(17)* For example, Kemmler et al.*(14)* investigated the impact of a high-frequency (>2 sessions per week) versus a low-frequency (<2 sessions per week) exercise intervention on muscle mass. The intervention was classified as multiple (endurance, balance and function, and resistance) with a duration of 78 weeks. The results showed that appendicular skeletal muscle mass increased significantly in the high-frequency exercise group compared to low-frequency exercise group (between-group difference 0.402 kg, 95% CI 0.095 to 0.708). Additionally, the study indicated that both groups increased lean body mass, with a greater increase in the high-frequency group but the between-group difference was not quite significant (0.534 kg, 95% CI -0.006 to 1.074, p =0.053).

Santos et al.*(17)* examined the effect of two different exercise intensities of exergame training (moderate vs vigorous) on frailty-related outcomes in pre-frail people. The intervention was classified as resistance training. The results showed that both groups improved muscle and functional capacity; however, the between-group difference was not reported.

Studies investigating different forms of physical activity

There was only one study*(3)* comparing two different forms of physical activity. Henwood et al.*(3)* investigated two different resistance training programmes, one aimed at enhancing muscle power and one at increasing muscle strength on frailty-related outcomes. The results indicated that interventions had positive effect on muscle strength, physical function and muscle mass. However, the effect estimates between groups were not reported.

CONSIDERATIONS

The initial aim of this review was to summarise the evidence of physical activity on prevention of frailty and sarcopenia in older people by conducting a review of systematic reviews. However, since no reviews were found we included the relevant individual studies that were included in the identified reviews. Since the search was targeted at reviews, it is possible that we have missed important studies, particularly recently published studies. In addition, the literature search was limited to PubMed and it is likely that we could have missed relevant studies.

We used an adapted version of the GRADE approach tabulating the number of studies that showed a positive, neutral or negative effect. Our impression is that a number of the included studies were too small to detect intervention effects if such effects existed.

One review author classified the exercise interventions using the ProFaNE guidelines*(22)* and a second one checked the classification. We recognise there is some subjectivity in this classification system, particularly for those interventions containing more than one category of exercise.

This review was unable to make firm statements about the optimal type of exercise or dose response associations are not possible at this stage. Studies that detected impacts on relevant outcomes involved resistance training, balance and functional exercises, endurance training, combinations of these and overall physical activity. There is an important need for more studies in this area so that more definitive advice can be provided. The studies investigating exercise programmes had a median duration of 5 months (mean=8 months). It is likely that longer exercise programmes would have larger effects on frailty and sarcopenia, as suggested by the only longitudinal study, but may suffer from feasibility issues as well as high dropout rates over time, which would reduce the external validity of their findings.

In summary, while the results need to be treated with some caution, the studies included in this review suggest that physical activity may play a role in the prevention of frailty and sarcopenia.

EVIDENCE PROFILE. The relationship between physical activity and frailty/sarcopenia prevention in older people

No. of studies	**Design**	**Quality assessment**					**No. of participants**	**Summary**	**Quality**
		Risk of bias	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**			
The association between physical activity and frailty prevention									
Only 1 RCT investigated the association between physical activity and frailty prevention. The follow-up length was 12 months. Frailty outcome was defined as the presence of three or more Fried criteria: (1) unintentional weight loss, (2) exhaustion, (3) low physical activity, (4) slow walking speed, and (5) poor grip strength.									
1	RCT[a]	Serious risk of bias[b]	No serious inconsistency[c]	No serious indirectness[d]	Serious imprecision[e]	None	133	Physical activity interventions may prevent frailty.[f]	Low[g]
The association between physical activity and sarcopenia prevention									
Only 1 longitudinal study investigated the association between physical activity and sarcopenia prevention. The follow-up length was 48 months. Sarcopenia was defined as low muscle mass, low muscle strength and/or low physical performance.									
1	Longitudinal study[h]	No serious risk of bias[i]	No serious inconsistency[j]	No serious indirectness[d]	Serious imprecision[k]	None	4,000	We are uncertain whether physical activity prevents sarcopenia.	Very low[m]
Exercise vs control on frailty-related outcomes									
A total of 4 RCTS investigated the effects of physical activity on frailty-related outcomes. The frailty-related outcomes were: (1) muscle mass measured with leg press with 1RM method, isokinetic dynamometer and hand dynamometer; (2) physical function measured with 6-m, 10-m and 12-m walk , Timed up and go and Short Physical performance Battery test (SPPB); (3) muscle mass measured with dual-energy x-ray absorptiometry (DXA).									
4	RCTs[n]	Serious risk of bias[o]	No serious inconsistency[p]	No serious indirectness[q]	Serious imprecision[r]	None	326	16/18 comparisons showed a positive effect for physical activity, 1/18 showed a neutral effect, and 1/18 showed negative effect for physical activity for frailty-related outcome. Physical activity interventions may prevent frailty-related outcomes.[s]	Low[t]
Exercise vs control on sarcopenia-related outcomes									
A total of 2 RCTs investigated the effects of physical activity on sarcopenia-related outcomes. The sarcopenia-related outcomes were: (1) muscle strength measured with isokinetic dynamometer; (2) muscle mass measured with dual-energy x-ray absorptiometry (DXA).									
2	RCTs[u]	Serious risk of bias[v]	No serious inconsistency[w]	No serious indirectness[q]	Serious imprecision[x]	None	204	All studies (4/4) showed a positive effect for physical activity on sarcopenia-related outcomes Physical activity interventions may prevent sarcopenia-related outcomes.[y]	Low[z]

[a] Includes 1 RCT*(18)*

[b] We downgraded the evidence by one level as the study had a PEDro score <6/10

[c] Not applicable

[d] Not applicable

[e] The single included study had a total of 133 participants analysed. Therefore, we downgraded the evidence.
[f] The effects for the study can be found in Table 3.
[g] Quality of the evidence was downgraded from high to low because of serious risk of bias and serious imprecision.
[h] Includes 1 longitudinal study *(20)*
[i] We did not downgrade the evidence as the study was at low risk of bias
[j] Not applicable.
[k] We downgraded the evidence as there was only one included study.
[l] The effects for the study can be found in Table 4.
[m] Quality of the evidence was downgraded from low to very low because of serious imprecision.
[n] Includes 4 RCTs.*(3, 15, 16, 19)*
[o] We downgraded the evidence by one level as 3/4 studies (75%) had a PEDro score <6/10.
[p] We did not downgrade the evidence due to heterogeneity of included studies as most comparisons (16/18 comparisons) showed a positive effect.
[q] Since we only included similar studies in terms of population, intervention, comparator and outcome, we did not downgrade the evidence based on this criterion.
[r] The 4 included studies had a total of 326 participants analysed. Therefore, we downgraded the evidence.
[s] The effects for each individual study can be found in Table 5.
[t] Quality of the evidence was downgraded from high to low because of serious risk of bias and serious imprecision.
[u] Includes 2 RCTs.*(13, 14)*
[v] We downgraded the evidence by one level as 1/2 studies (50%) had a PEDro score <6/10.
[w] We did not downgrade the evidence due to heterogeneity of included studies as all comparisons (4/4 comparisons) showed a positive effect.
[x] The 2 RCTs had a total of 204 participants analysed. Therefore, we downgraded the evidence.
[y] The effects for each individual study can be found in Table 6.
[z] Quality of the evidence was downgraded from high to low because of serious risk of bias and serious imprecision.

REFERENCES FOR EVIDENCE PROFILE

1. Serra-Prat M, Sist X, Domenich R, et al. Effectiveness of an intervention to prevent frailty in pre-frail community-dwelling older people consulting in primary care: a randomised controlled trial. *Age Ageing* 2017;46(3):401-07.
2. Yu R, Wong M, Leung J, et al. Incidence, reversibility, risk factors and the protective effect of high body mass index against sarcopenia in community-dwelling older Chinese adults. *Geriatr Gerontol Int* 2014;14 Suppl 1:15-28.
3. Henwood TR, Riek S, Taaffe DR. Strength versus muscle power-specific resistance training in community-dwelling older adults. *J Gerontol A Biol Sci Med Sci* 2008;63(1):83-91.
4. Lustosa LP, Silva JP, Coelho FM, et al. Impact of resistance exercise program on functional capacity and muscular strength of knee extensor in pre-frail community-dwelling older women: a randomized crossover trial. *Rev Bras Fisioter* 2011;15(4):318-24.
5. Oh SL, Kim HJ, Woo S, et al. Effects of an integrated health education and elastic band resistance training program on physical function and muscle strength in community-dwelling elderly women: Healthy Aging and Happy Aging II study. *Geriatr Gerontol Int* 2017;17(5):825-33.
6. Wolf SL, Barnhart HX, Kutner NG, et al. Selected as the best paper in the 1990s: Reducing frailty and falls in older persons: an investigation of tai chi and computerized balance training. *J Am Geriatr Soc* 2003;51(12):1794-803.
7. Goodpaster BH, Chomentowski P, Ward BK, et al. Effects of physical activity on strength and skeletal muscle fat infiltration in older adults: a randomized controlled trial. *J Appl Physiol (1985)* 2008;105(5):1498-503.
8. Kemmler W, von Stengel S. Exercise frequency, health risk factors, and diseases of the elderly. *Arch Phys Med Rehabil* 2013;94(11):2046-53.

FIGURE 1. Flow of studies

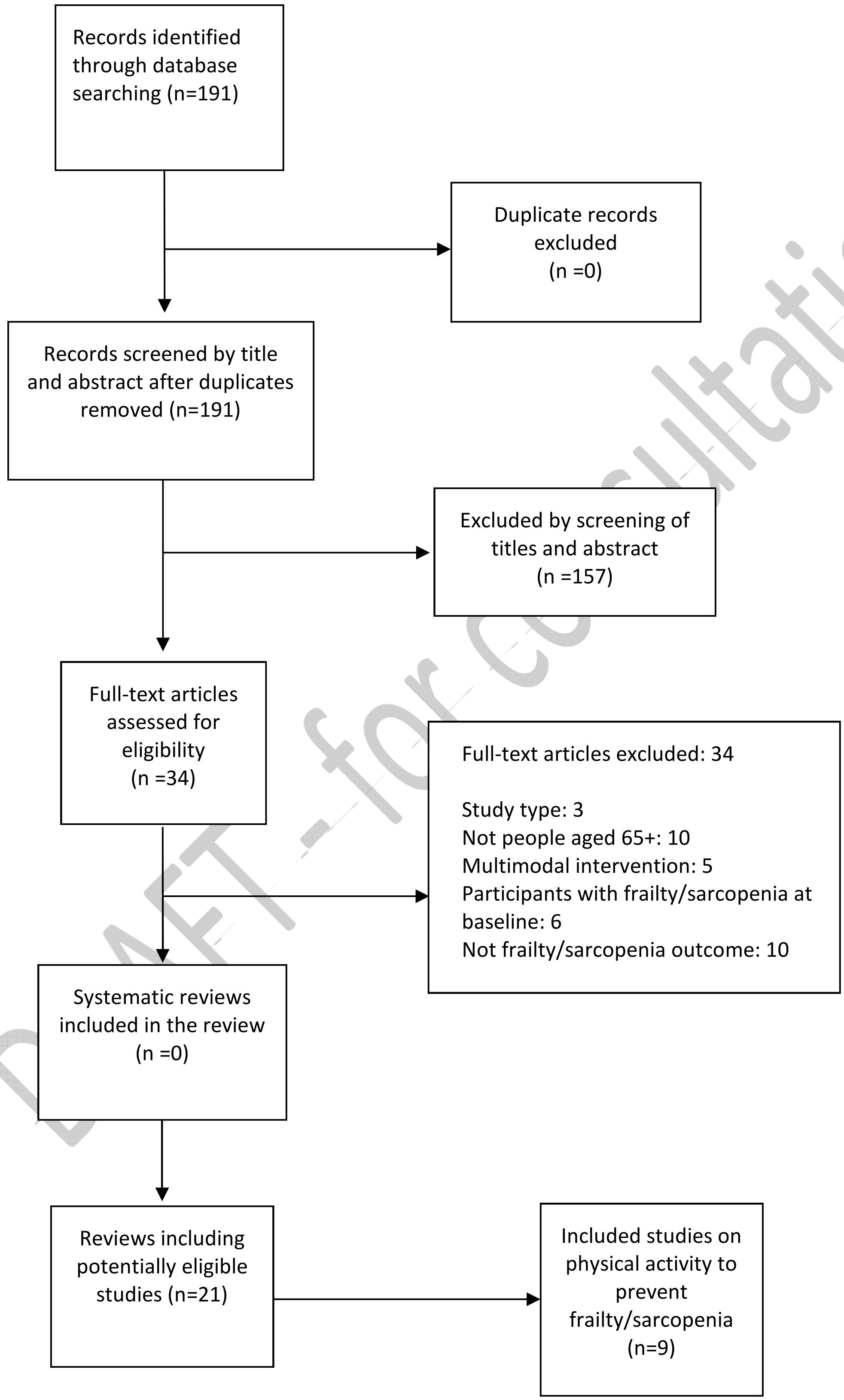

FIGURE 2. Effect of physical activity interventions on muscle strength

Effect size (95% confidence interval) of physical activity interventions on muscle strength by pooling data from 2 studies comparing physical activity versus control using random-effects meta-analysis (n=225)

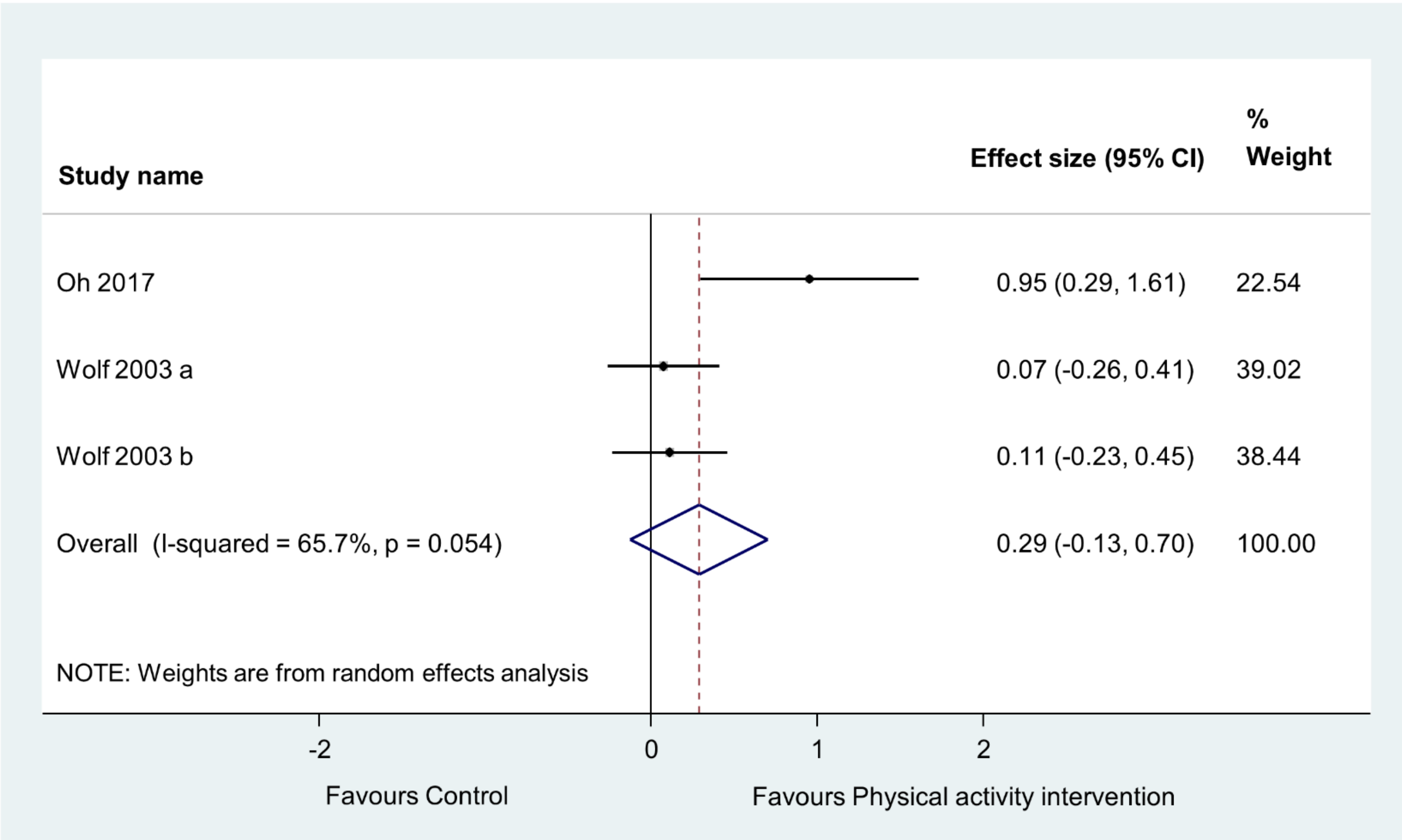

FIGURE 3. Effect of physical activity interventions on physical performance

Effect size (95% confidence interval) of physical activity interventions on physical performance by pooling data from 4 studies comparing physical activity versus control using random-effects meta-analysis (n=326)

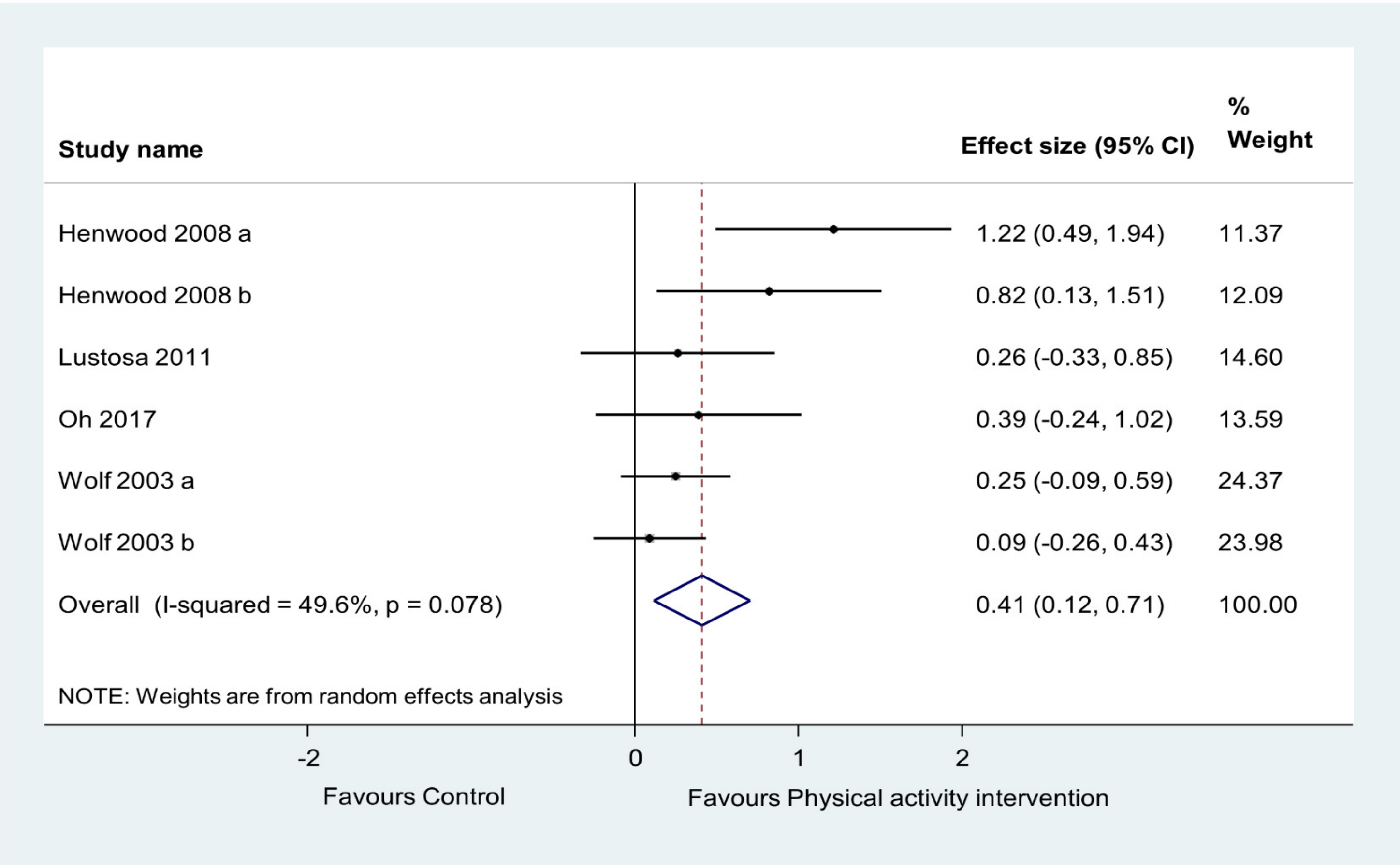

FIGURE 4. Effect of physical activity interventions on muscle mass

Effect size (95% confidence interval) of physical activity interventions on muscle mass by pooling data from 3 studies comparing physical activity versus control using random-effects meta-analysis (n=253)

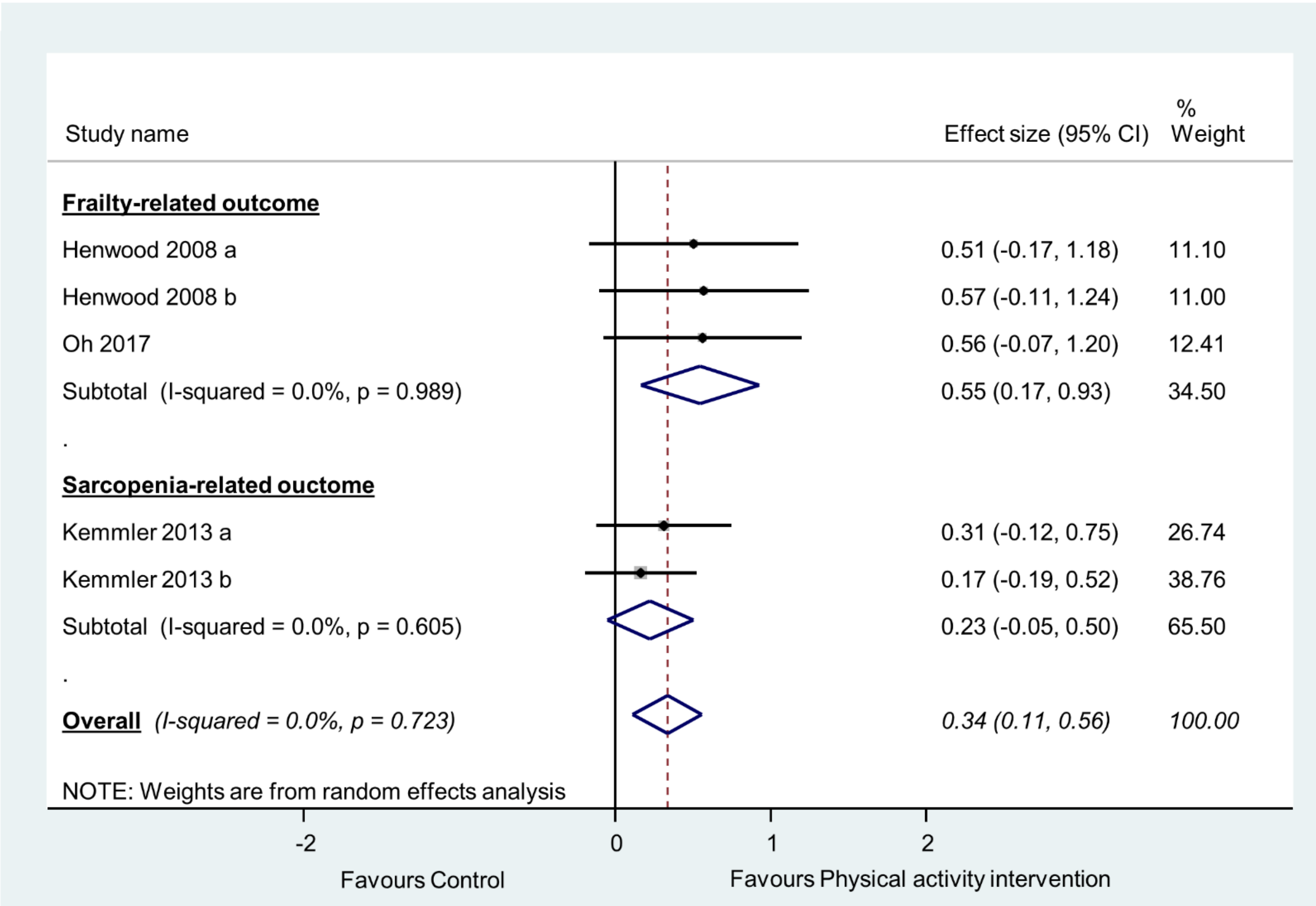

TABLE 1. Description of included studies

Reference **PEDro score**	**Study design** Randomised/ analysed	**Participants (setting, health status; n, age mean (SD), % female by group)**	**Intervention/ exposure** **Primary exercise type according to ProFANE**	**Control**	**Outcomes**	**Follow up**	**Results**
Goodpaster et al. (2008) 5/10	RCT 52/42	**Setting:** Community; United States **Health status:** Healthy **<u>A. Intervention group</u>** **N:** 22 (analysed) **Age:** 76.7 (1.0) **Female:** 77% **<u>B. Control group</u>** **N:** 20 (analysed) **Age:** 77.4 (1.0) **Female:** 70%	**A.** Physical activity intervention including aerobic, strength, flexibility, and balance training, supplemented by home-based exercise. **Duration of the intervention (weeks):** 25 **Frequency:** 2 to 5 sessions/week. *Week 1-8: 3 sessions/week* *Week 9-24: 2 sessions/week* *Week 25 to the end of the trial: 5 sessions/week)* **Session duration (min):** 40-60 **Delivered by:** Not reported **Primary exercise type**: endurance (walking)	**B.** Health education sessions	**1. Muscle strength:** knee extensor strength measured with Kin-Com dynamometer **2. Muscle mass:** thigh muscle measured with axial CT scan	52 weeks	**1. Muscle strength:** No between-group difference was found (p=0.06) A. Intervention: 1.5% muscle strength loss (No SD reported) B. Control: 21.6± 10% muscle strength loss **2. Muscle mass:** No between-group difference was found. A. Intervention group (change score ± SD[a]): 4 ±1% muscle mass loss B. Control group (change score ± SD[a]): 3 ±1% muscle mass loss
Henwood et al. (2008) 4/10	RCT 67/53	**Setting:** Community; Australia **Health status:** Healthy **<u>A. High velocity training group:</u>** **N:** 23 (randomised); 19 (analysed) **Age:** 71.2 (1.3) **Female:** 63% **<u>B. Strength training group:</u>** **N:** 22 (randomised); 19 (analysed) **Age:** 69.6 (1.1) **Female:** 47% **<u>C. Control group:</u>** **N:** 22 (randomised); 15 (analysed)	**A & B.** Supervised progressive resistance training. **Duration of the intervention (weeks):** 24 **Frequency:** 2 sessions/week **Session duration (min):** 60 **Delivered by:** Exercise instructor **<u>A. High velocity training intervention:</u>** Resistance training aiming at increasing muscle power. **Intensity:** Rapid concentric phase of each repetition, and slow and controlled eccentric phase. Set 1: 8 reps at 45% 1RM Set 2: 8 reps at 60% 1RM	**C.** No intervention	**1. Dynamic muscle strength and muscle endurance:** leg press measured with 1RM method **2. Functional performance:** measured with usual 6-m walk; repeated chair rise to standing (5 times) **3. Lean body mass:** assessed with dual-energy x-ray absorptiometry (DXA) technique	24 weeks	**1. Dynamic muscle strength and muscle endurance:** Increased significantly between groups compared to control (p< 0.001). There was no difference between exercise groups for muscle strength. A. High velocity training group (change score ± SD[a]): 51.0 ±9.0% B. Strength group (change score ± SD[a]): 48.3 ±6.8% C. Control group (change score ± SD[a]): 1.2 ±5.1% **2. Functional performance:** <u>-Usual 6-m walk:</u>

		Age: 69.3(1.0) **Female:** 60%	Set 3: ≥8 reps at 75% 1RM **Primary exercise type**: resistance **<u>Strength training intervention</u>**: Resistance training aiming at increasing muscle strength. **Intensity:** 3 sets of 8 repetitions at 75% RM. Speed of 3s per concentric and eccentric phase. **Primary exercise type**: resistance				Did not increase significantly between both training groups and control (p=0.064). No between-training group differences were found. A. High velocity training group (final score ±SE): 4.04 ±0.08s B. Strength group (final score ± SE): 3.81 ±0.08s C. Control group (final score ± SE): 4.09 ±0.09s <u>-Chair rise:</u> Increased significantly between both training groups compared to control (p=0.002). No between-training group differences were found. A. High velocity training group (final score ±SE): 10.26 ±0.38s B. Strength group (final score ± SE): 10.99 ±0.39s C. Control group (final score ± SE): 12.56 ±0.43s **3. Lean body mass:** Only within-group comparisons were reported. A. High velocity training group (change score ± SD[a]): 1.2 ±0.2kg B. Strength group (change score ± SD[a]): 1.4 ±0.3kg C. Control group (change score ± SD[a]): 0.6 ±0.3kg
Kemmler et al. (2013) 6/10	RCT 246/162	**Setting:** Community; Germany **Health status:** Healthy **<u>A. High frequency exercise</u>** **N:** 79 (included and analysed) **Age:** 68.6(3.9) **<u>B. Low frequency exercise</u>** **N:** 36 (included and analysed) **Age:** 69.5 (3.8) **<u>C. Control</u>** **N:** 47 (included and analysed)	**A & B.** Supervised group-based exercise programme consisting of aerobic dance, balance and resistance training, supplemented by home training sessions. **Duration of the intervention (weeks):** 78 **Frequency:** Low-frequency group: <2 sessions/week High- frequency group ≥2 sessions/week	**C**. Low-intensity physical activity and relaxation training.	**1. Lean body mass (LBM) and appendicular skeletal muscle mass (ASMM):** assessed with dual-energy x-ray absorptiometry (DXA) technique	78 weeks	Between-group difference (95% CI): **1. LBM:** 0.534 kg (-0.006 to 1.074) **2. ASMM:** 0.402 kg (0.095 to 0.708)

		Age: 69.5 (4.5) **Female:** 100 % [only included female in the original study]	**Session duration (min):** 60min (supervised group session), 20min (non-supervised home training session) **Delivered by:** exercise instructor **Primary exercise type**: Multiple: endurance (aerobic dance) plus balance and function plus resistance				
Lustosa et al. (2011) 6/10	Crossover RCT 32/48	**Setting:** Community; Brazil **Health status:** Pre-frail **<u>A. Intervention group:</u>** **N:** 32 **Age:** 72 (4) **<u>B. Control group:</u>** **N:** 16 **Age:** 72 (3.5) **Female:** 100% [only included female in this study]	**A.** Supervised training including open and closed kinetic chain of large muscle groups with the use of ankle weights **Duration of the intervention (weeks):** 10 **Frequency:** 3 sessions/week **Session duration (min):** 60 **Delivered by:** physiotherapist **Primary exercise type**: resistance (functional)	**B.** No intervention	**1. Knee extensors muscle strength**: assessed by isokinetic dynamometer *Byodex System 3 Pro@* at 60⁰/s **2. Functional performance:** assessed by Timed up and go (TUG) and the 10-meter walk test (10MWT)	10 weeks	**1. Muscle strength:** Only within-group comparisons were reported. A. Intervention group (final score ±SD): 122.36 ±33.2% B. Control group (final score ±SD): 128.95 ±38.8% **2. Functional performance:** Functional performance increased significantly in the intervention group compared to control (P<0.01). -<u>TUG:</u> A. Intervention group (final score ±SD): 10.41 ±1.9s B. Control group (final score ±SD): 10.9 ±1.7s -<u>10-m walk:</u> A. Intervention group (final score ±SD): 4.36 ± 0.7s B. Control group (final score ±SD): 4.87± 0.8
Oh et al. (2017) 4/10	RCT 80/ 38	**Setting:** Community; Korea **Health status:** Healthy **<u>A. Intervention group:</u>** **N:**40 (randomised); 19 (analysed) **Age:** 74.9 (1.5) **<u>B. Control:</u>**	**A**. Multi-component intervention including health education, individual counselling and supervised elastic band resistance training. Additional self-directed training. **Duration of the intervention (weeks):** 18 **Frequency:** 2 sessions/week	**B.** Supervised one-hour stretching (static and dynamic).	**1. Muscle strength:** knee extensor measured with isokinetic dynamometer at 60⁰/s **2. Physical function:** assessed using SPPB	18 weeks	**1. Muscle strength:** Increased significantly compared to control (p<0.001) A. Intervention group (final score ±SE): 126.5 ± 8.6 (Nm) B. Control group (final score ±SE) 94.7 ± 6.2 (Nm)

		N: 40 (randomised); 19 (analysed) **Age:** 73.5 (1.2) **Female:** 100% [only included female in this study]	**Intensity:** 2-3 sets of 10-20 reps; intensity increased every 4 weeks. **Session duration (min):** 60 **Delivered by:** Expert trainers **Primary exercise type**: resistance		**3. Body composition:** skeletal muscle index assessed using dual-energy X-ray absorptiometry (DXA)		**2. Physical function:** Improved significantly SPPB score compared to control (p=0.006) A. Intervention group (final score, 95% CI): 10.4 (9.6–11.3) B. Control group (final score, 95% CI): 9.7 (8.8–10.5) **3. Body composition:** No between-group differences (p=0.348) A. Intervention group (final score, SE): 6.8± 0.2 ASM/ height^2 B. Control group (final score, SE): 6.3± 0.2 ASM/ height^2
Santos et al. (2018) 3/10	RCT 34/20	**Setting:** Community; Brazil **Health status:** Pre-frail **<u>A. Moderate intensity exergame group:</u>** **N:** 17 (randomised); 11 (analysed) **Age:** 69.7 (5.6) **<u>B. Vigorous intensity exergame group:</u>** **N:** 17 (randomised); 9 (analysed) **Age:** 69.1 (5.0) **Female:** 100% [only included female in this study]	**A & B.** Exercise game routines including strength exercises, dynamic balance and cardiorespiratory exercise. **Duration of the intervention (weeks):** 12 **Frequency:** 3 times/week **Session duration (min):** 40 **Intensity:** Week 1: 4 sets of 8 reps Week 2-6: progressed to 4 sets of 12 reps Week 7-9: 6 sets of 12 repetitions Week 10-12: and 6 sets of 16 reps **Delivered by:** a qualified instructor **<u>A. Moderate intensity exergame group:</u>** 11 to 13 rate of perceived exertion (RPE) on Borg 6-20 Scale **Primary exercise type**: resistance (functional) **<u>B. Vigorous intensity exergame group:</u>** Added increment of weight in the vest from 3% of body mass up to 10% of body mass. 14 to 16 RPE	N/A [No control group]	**1. Muscle strength:** knee extensor measured with isokinetic dynamometer at 60^0/s **2.Functional capacity:** measured with sit to stand (STS), timed up and go (TUG) and 10m walk test	12 weeks	**1. Muscle strength:** A. Moderate intensity exergame group (final score ±SE): 115.2 ± 22.6 (N.m/kg) B. Vigorous intensity exergame group (final score ±SE) (knee extensor): 120.2 ± 21.3 (N.m/kg) 2**. Functional capacity:** -<u>Sit to stand:</u> Only within-group comparisons were reported. A. Moderate intensity exergame group (final score ±SE): 10.3 ± 3.2 B. Vigorous intensity exergame group (final score ±SE): Sit to stand (s): 8.4 ± 1.6 -<u>TUG:</u> Moderate group reduced significantly the time of the test compared to vigorous group (p=0.001) A. Moderate intensity exergame group (final score ±SE): 8.1 ± 1.6s B. Vigorous intensity exergame group (final score ±SE): 8.5 ± 0.9s <u>10-m walk test:</u> No between-group difference (p=0.81) A. Moderate intensity exergame group (final score ±SE): 1.41 ± 0.24s

			Primary exercise type: resistance (functional)				B. Vigorous intensity exergame group (final score ±SE): 1.60 ± 0.21s
Serra-Prat et al. (2017) 5/10	RCT 172/ 133	**Setting:** Community; Spain **Health status:** Pre-frail **<u>A. Intervention group:</u>** **N:**80 (randomised); 61 (analysed) **Age:** 77.9 (5.0) **Female:** 51.3% **<u>B. Control group:</u>** **N:** 92 (randomised); 72 (analysed) **Age:** 78.8 (4.9) **Female:** 60.9%	**A.** Physical activity programme including aerobic exercise (outdoor walking) and a combined resistance, balance and coordination training. **Duration of the intervention (weeks):** 52 **Frequency:** 4 times/week **Session duration (min):** Walking: 30-45 min Mixed exercise: 20-25 min **Intensity:** Each exercise was repeated 10 -15 times a minute with a rest of 30 seconds between each set of the exercise **Delivered by:** Not reported **Primary exercise type**: Multiple (endurance plus balance and function)	**B.** Usual care	**1. Prevalence of frailty**: presence of three or more Fried criteria)	52 weeks	1. Odds ratio adjusted for baseline (OR, 95% CI): 0.19 (0.04–0.95)

Wolf et al. 1996 5/10	RCT 200/187	**Setting:** Community; United States **Health status:** Healthy **A. Tai Chi group:** **N:** 72 (randomised and analysed) **Age:** 76.9 (4.8) **Female:** 81% **B. Computerized balance training group:** **N:** 64 (randomised and analysed) **Age:** 76.3 (5.1) **Female:** 77% **C. Control group:** **N:** 64 (randomised and analysed) **Age:** 75.4 (4.1) **Female:** 84%	**A. Tai Chi intervention:** Group-based programme involving 10 forms of Tai chi. **Duration of the intervention (weeks):** 15 **Frequency:** 2 sessions/week **Session duration (min):** at least 15 min (home) and 45 min (instructor) **Intensity:** Progression involved a gradual reduction of the base of standing support. **Delivered by:** Tai chi instructor **Primary exercise type**: 3D Tai Chi **B. Computerized balance training intervention:** Individualised training using a Balance system which involved the movement of the centre of mass without foot displacement **Duration of the intervention (weeks):** 15 **Frequency:** 1 session/week **Intensity:** Progressive increase sway to the limits of postural stability. **Session duration (min):** 45 **Delivered by:** instructor **Primary exercise type**: Balance and function	**C.** Group-based health education sessions.	**1.Indicators of frailty that included:** A. Strength assessed using grip strength assessed by the Jamar Smedley-type hand dynamometer B. Cardiovascular endurance measured by 12-minute walk	16 weeks	**1. Grip strength:** showed differences for the three intervention groups (p=0.025). It is more likely to decline over time in the balance training and control group than in the tai chi group. A. Tai Chi group (final score ±SD): 22.87± 8.1 B. Computerized balance training group (final score ±SD): 23.8± 8.0 C. Control group (final score ±SD): 22.2± 6.6 **2. Cardiovascular endurance:** showed significant differences in the distance ambulated over 12 minutes for the three intervention groups (p=0.040) A. Tai Chi group (final score ±SD): 0.55± 0.10 miles B. Computerized balance training group (final score ±SD): 0.57± 0.08 C. Control group (final score ±SD): 0.58 ± 0.11

Yu et at. (2014) N/A	Observational 4000 (included and analysed)	**Setting:** Community: Hong Kong **Health status:** Mixed (9% of participants had sarcopenia) **N:** 4000 (included and analysed) **Age:** 72.5 (5.2) **Female:** 50%	Overall physical activity assessed using the Physical Activity Scale of the Elderly (PASE).	N/A	Sarcopenia status defined as low muscle mass, low muscle strength and/or low physical performance. Low muscle mass was defined as appendicular skeletal muscle mass (ASM) index (ASM/height^2) <6.52 kg/m^2 for males and <5.44 kg/m^2 for females. Low muscle strength was defined as grip strength ≤28 kg for males and ≤18 kg for females. Low physical performance as gait speed ≤ 0.8 m/s for both males and females.	48 months	Physical activity associated with incident sarcopenia after adjustment (OR, 95% CI): adjusted 0.995 (0.991–0.999)

N/A: not applicable; RCT: randomised controlled trial; SD: Standard deviation; SE: Standard error; CT: Computed tomography; 1RM: One-repetition maximum; SPPB: Short Physical Performance Battery. [a]We assumed SD; however, it is not clearly stated in the results.
We only included and extracted information for the groups and for the comparisons that were relevant to this study (i.e., those where the effect of physical activity could be evaluated). When data was available for more than one time-point, we extracted the post-intervention data. Mean estimates were extracted in the following hierarchical order: mean difference, change score and final score. Shading indicates studies which detected a statistically significant between-group difference in frailty, sarcopenia or one of the components of frailty or sarcopenia.

TABLE 2. Description of included studies investigating the association between different types and doses of physical activity on prevention of frailty and sarcopenia

Reference PEDro score	Study design Allocated/ Analysed	Participants (n, age mean (SD), % women, setting, health status)	Intervention Primary exercise type according to ProFANE	Relevant comparison	Outcomes	Follow up (weeks)	Results
Henwood et al. (2008) * 4/10	RCT 67/53	**Setting:** Community; Australia **Health status:** Healthy **A. High velocity training group:** **N:** 23 (randomised); 19 (analysed) **Age:** 71.2 (1.3) **Female:** 63% **B. Strength training group:** **N:** 22 (randomised); 19 (analysed) **Age:** 69.6 (1.1) **Female:** 47% **C. Control group:** Not relevant for this comparison	**A & B.** Supervised progressive resistance training. **Duration of the intervention (weeks):** 24 **Frequency:** 2 sessions/week **Session duration (min):** 60 **Delivered by:** Exercise instructor **A. High velocity training intervention:** Resistance training aiming at increasing muscle power. **Intensity:** Rapid concentric phase of each repetition, and slow and controlled eccentric phase. Set 1: 8 reps at 45% 1RM Set 2: 8 reps at 60% 1RM Set 3: ≥8 reps at 75% 1RM **Primary exercise type**: resistance **B. Strength training intervention**: Resistance training aiming at increasing muscle strength. **Intensity:** 3 sets of 8 repetitions at 75% RM. Speed of 3s per concentric and eccentric phase. **Primary exercise type**: Resistance	A vs B	**1. Dynamic muscle strength and muscle endurance:** leg press and chest press measured with 1RM method **2. Functional performance:** measured with usual 6-m walk; repeated chair rise to standing (5 times) **3. Lean body mass:** assessed with dual-energy x-ray absorptiometry (DXA) technique	24	**1. Dynamic muscle strength and muscle endurance:** A. High velocity training group (change score ± SD[a]): 51.0 ±9.0% B. Strength group (change score ± SD[a]): 48.3 ±6.8% **2. Functional performance:** -Usual 6-m walk: A. High velocity training group (final score ±SE): 4.04 ±0.08s B. Strength group (final score ± SE): 3.81 ±0.08s -Chair rise: A. High velocity training group (final score ±SE): 10.26 ±0.38s B. Strength group (final score ± SE): 10.99 ±0.39s **3. Lean body mass:** A. High velocity training group (change score ± SD[a]): 1.2 ±0.2kg B. Strength group (change score ± SD[a]): 1.4 ±0.3kg
Kemmler et al. (2013) * 6/10	RCT 246/162	**Setting:** Community; Germany **Health status:** Healthy **Female:** 100 % [only included female in the original study] **A. High frequency exercise** **N:** 79 (included and analysed) **Age:** 68.6(3.9) **B. Low frequency exercise** **N:** 36 (included and analysed) **Age:** 69.5 (3.8)	**A & B.** Supervised group-based exercise programme consisting of aerobic dance, balance and resistance training, supplemented by home training sessions. **Duration of the intervention (weeks):** 78 **Frequency:** Low-frequency group: <2 sessions/week High- frequency group ≥2 sessions/week **Session duration (min):** 60min (supervised group session), 20min (non-supervised home training session) **Delivered by:** Exercise instructor	A vs B	**1. Lean body mass (LBM) and appendicular skeletal muscle mass (ASMM):** assessed with dual-energy x-ray absorptiometry (DXA) technique	78	Between-group difference (95% CI): **1. LBM:** 0.534 kg (-0.006 to 1.074) **2. ASMM:** 0.402 kg (0.095 to 0.708)

		C. Control: Not relevant for this comparison	**Primary exercise type**: Multiple: endurance (aerobic dance) plus balance and function plus resistance				
Santos et al. (2018) 3/10	RCT 34/20	**Setting:** Community; Brazil **Health status:** Pre-frail **Female:** 100% [only included female in this study] **Moderate intensity exergame group:** **N:** 17 (randomised); 11 (analysed) **Age:** 69.7 (5.6) **Vigorous intensity exergame group:** **N:** 17 (randomised); 9 (analysed) **Age:** 69.1 (5.0)	**A & B.** Exercise game routines including strength exercises, dynamic balance and cardiorespiratory exercise. **Duration of the intervention (weeks):** 12 **Frequency:** 3 times/week **Session duration (min):** 40 **Intensity:** Week 1: 4 sets of 8 reps Week 2-6: progressed to 4 sets of 12 reps Week 7-9: 6 sets of 12 repetitions Week 10-12: and 6 sets of 16 reps **Delivered by:** A qualified instructor **A. Moderate intensity exergame group:** 11 to 13 rate of perceived exertion (RPE) on Borg 6-20 Scale **Primary exercise type**: Resistance (functional) **B. Vigorous intensity exergame group:** Added increment of weight in the vest from 3% of body mass up to 10% of body mass. 14 to 16 RPE **Primary exercise type**: Resistance (functional)	A vs B	**1. Muscle strength:** knee extensor measured with isokinetic dynamometer at 60^0/s **2.Functional capacity:** measured with sit to stand (STS), timed up and go (TUG) and 10m walk test	12	**1. Muscle strength:** A. Moderate intensity exergame group (final score ±SE): 115.2 ± 22.6 (N.m/kg) B. Vigorous intensity exergame group (final score ±SE) (knee extensor): 120.2 ± 21.3 (N.m/kg) 2**. Functional capacity:** -Sit to stand: Only within-group comparisons were reported. A. Moderate intensity exergame group (final score ±SE): 10.3 ± 3.2 B. Vigorous intensity exergame group (final score ±SE): Sit to stand (s): 8.4 ± 1.6 -TUG: Moderate group reduced significantly the time of the test compared to vigorous group (p=0.001) A. Moderate intensity exergame group (final score ±SE): 8.1 ± 1.6s B. Vigorous intensity exergame group (final score ±SE): 8.5 ± 0.9s 10-m walk test: no between-group difference (p=0.81) A. Moderate intensity exergame group (final score ±SE): 1.41 ± 0.24s B. Vigorous intensity exergame group (final score ±SE): 1.60 ± 0.21s

RCT: randomised controlled trial; SD: Standard deviation; SE: Standard Error. When data was available for more than one time-point, we extracted the post-intervention data. [a]We assumed SD; however, it is not clearly stated in the results.
Mean estimates were extracted in the following hierarchical order: mean difference, change score and final score.
*Indicate studies also included in the exercise vs control comparison (Table 1), but only the results for different doses of exercise are presented here.
Shading indicates studies which detected a statistically significant between-group difference in frailty, sarcopenia or one of the components of frailty or sarcopenia.

TABLE 3. Overview of results of included studies on frailty outcome

Reference PEDro score	Study design Randomised/ Analysed	Intervention/ exposure	Control	Outcome	Follow up (mo)	Results	Effect
Serra-Prat et. Al (2017) 5/10	RCT 172/ 133	Multiple (endurance plus balance and function)	Usual care	Prevalence of frailty defined as the presence of three or more Fried criteria	12	1. Odds ratio adjusted for baseline (OR, 95% CI): 0.19 (0.04–0.95)	Pos/Sig

N/A: Nor applicable; RCT: randomised controlled trial; Pos: positive effect of physical activity on the outcome; Neg: negative effect of physical activity on the outcome; Neu: neutral effect; Sig: statistically significant. Shading indicates studies which detected a statistically significant between-group difference in frailty., sarcopenia or one of the components of frailty or sarcopenia.

TABLE 4. Overview of results of included studies on sarcopenia outcome

Reference **PEDro score**	**Study design** **Randomised/ Analysed**	**Intervention/ exposure**	**Control**	**Outcome**	**Follow up (mo)**	**Results**	**Effect**
Yu et al. (2014) N/A	Observational 4000 (included and analysed)	Overall physical activity assessed using the Physical Activity Scale of the Elderly (PASE).	N/A	Sarcopenia status defined as low muscle mass, low muscle strength and/or low physical performance.	48	Physical activity associated with incident sarcopenia after adjustment (OR, 95% CI): adjusted 0.995 (0.991–0.999)	Pos/Sig

N/A: Nor applicable; RCT: randomised controlled trial; Pos: positive effect of physical activity on the outcome; Neg: negative effect of physical activity on the outcome; Neu: neutral effect; Sig: statistically significant. Shading indicates studies which detected a statistically significant between-group difference in frailty, sarcopenia or one of the components of frailty or sarcopenia.

TABLE 5. Overview of included studies comparing physical activity with a control intervention on frailty-related outcomes

Reference PEDro score	Study design Randomised/ Analysed	Intervention according to ProFANE	Control	Follow up (wk)	Results	Effect
Henwood et al. (2008) 4/10	RCT 67/53	A. Resistance training (High velocity) B. Resistance training	C. No exercise	24	**1. Dynamic muscle strength and muscle endurance:** A. High velocity training group (change score ± SD[a]): 51.0 ±9.0% B. Strength group (change score ± SD[a]): 48.3 ±6.8% C. Control group (change score ± SD[a]): 1.2 ±5.1%	i. Pos/ S (A vs C) ii. Pos/ S (B vs C)
					2. Functional performance: 2.1. Usual 6-m walk: A. High velocity training group (final score ±SE): 64.04 ±0.08s B. Strength group (final score ± SE): 63.81 ±0.08s C. Control group (final score ± SE): 64.09 ±0.09s	i. Neu/NS (A vs C) ii. Pos/Ns (B vs C)
					2.2. Chair rise: A. High velocity training group (final score ±SE): 10.26 ±0.38s B. Strength group (final score ± SE): 10.99 ±0.39s C. Control group (final score ± SE): 12.56 ±0.43s	i. Pos/S (A vs C) ii. Pos/S (B vs C)
					3. Lean body mass: A. High velocity training group (change score ± SD[a]): 1.2 ±0.2kg B. Strength group (change score ± SD[a]): 1.4 ±0.3kg C. Control group (change score ± SD[a]): 0.6 ±0.3kg	i.Pos/S (A vs c) ii. Pos/S (B vs C)
Lustosa et al. (2011) 6/10	Crossover RCT 32/48	A. Resistance (functional) training	B. Low level exercise	10	**1. Muscle strength:** A. Intervention group (final score ±SD): 122.36 ±33.2% B. Control group (final score ±SD): 128.95 ±38.8%	i. Neg / NS
					2. Functional performance: 2.1.TUG: A. Intervention group (final score ±SD): 10.41 ±1.9s B. Control group (final score ±SD): 10.9 ±1.7s	i.Pos/ NS

					2.2. 10-m walk: A. Intervention group (final score ±SD): 4.36 ± 0.7s B. Control group (final score ±SD): 4.87± 0.8	i.Pos/NS
Oh et al. (2017) 4/10	RCT 80/ 38	A. Resistance training	B. Low level exercise	18	**1. Muscle strength:** A. Intervention group (final score ±SE): 126.5 ± 8.6 (Nm) B. Control group (final score ±SE) 94.7 ± 6.2 (Nm)	i. Pos/S
					2. Physical function: A. Intervention group (final score, 95% CI): 10.4 (9.6–11.3) B. Control group (final score, 95% CI): 9.7 (8.8–10.5)	i. Pos/S
					3. Body composition: A. Intervention group (final score, SE): 6.8± 0.2 ASM/ height^2 B. Control group (final score, SE): 6.3± 0.2 ASM/ height^2	i. Pos/NS
Wolf et al. 1996 5/10	RCT 200/187	A. 3D Tai Chi B. Balance/function exercise	B. Control	15	**1. Grip strength:** A. Tai Chi group (final score ±SD): 22.87± 8.1 B. Computerized balance training group (final score ±SD): 23.8± 8.0 C. Control group (final score ±SD): 22.2± 6.6	i. Pos/NS (A vs C) ii.Pos/S (B vs C)
					2. Cardiovascular endurance: A. Tai Chi group (final score ±SD): 0.55± 0.10 miles B. Computerized balance training group (final score ±SD): 0.57± 0.08 C. Control group (final score ±SD): 0.58 ± 0.11	i.Pos/S (A vs C) ii.Pos/S (B vs C)

RCT: randomised controlled trial; Pos: positive effect of physical activity on the outcome; Neg: negative effect of physical activity on the outcome; Neu: neutral effect; Sig: statistically significant; NS: non-statistically significant. [a]We assumed SD; however, it is not clearly stated in the results. *When data were available for more than one time-point, we extracted the post-intervention data. Mean estimates were extracted in the following hierarchical order: mean difference, change score and final score. Shading indicates studies which detected a statistically significant between-group difference in frailty, sarcopenia or one of the components of frailty or sarcopenia.

TABLE 6. Overview of results of included studies comparing physical activity with a control intervention on sarcopenia-related outcomes

Reference **PEDro score**	**Study design** **Randomised/ Analysed**	**Intervention**	**Control**	**Follow up (week)**	**Results**	**Effect**
Goodpaster et al. (2008) 5/10	RCT 52/42	A. Endurance (walking)	B. Low level exercise	52	**1. Muscle strength:** A. Intervention: 1.5% muscle strength loss (No SD reported) B. Control: 21.6± 10% muscle strength loss	i.Pos/ NS
					2. Muscle mass: A. Intervention group (change score ± SD[a]): 4 ±1% muscle mass loss B. Control group (change score ±e SD[a]): 3 ±1% muscle mass loss	i. Pos/NS
Kemmler et al. (2013) 6/10	RCT 246/162	A. Multiple: (endurance (aerobic dance) plus balance and function plus resistance)	B. Control	78	Between-group difference (95% CI): **1. Lean body mass:** 0.534 kg (-0.006 to 1.074) **2. appendicular skeletal muscle mass**: 0.402 kg (0.095 to 0.708)	i.Pos/NS ii. Pos/S

RCT: randomised controlled trial; Pos: positive effect of physical activity on the outcome; Neg: negative effect of physical activity on the outcome; Neu: neutral effect; Sig: statistically significant; NS: non-statistically significant.[a] We assumed SD; however, it is not clearly stated in the results. *When data were available for more than one time-point, we extracted the post-intervention data. Mean estimates were extracted in the following hierarchical order: mean difference, change score and final score. Shading indicates studies which detected a statistically significant between-group difference in frailty, sarcopenia or one of the components of frailty or sarcopenia.

APPENDIX 1. Eligibility criteria

Category	Inclusion/Exclusion Criteria	Notes/Rationale
Publication Language	**Include:** • Studies published with full text in English	
Date of Publication	**Include:** • Systematic reviews and meta-analyses published from 2008 – 2019	
Publication Status	**Include:** • Studies published in peer-reviewed journals **Excluded:** • Grey literature, including unpublished data, abstracts, conference proceedings	
Research Type	**Include:** • Systematic reviews • Meta-analyses **Exclude:** • Narrative reviews • Commentaries • Editorials • Systematic review protocols	
Characteristics of studies included in the reviews		
Study design of studies included in the reviews	**Include:** • Randomized controlled trials • Non-randomized controlled trials • Prospective cohort studies • Retrospective cohort studies • Systematic reviews • Meta-analyses **Exclude:** • Cross-sectional studies • Before-and-after studies	

Study Subjects	**Include:** • Human subjects • Adults aged 65 and older	• When data are analysed by age groups, only data with lower range of 64 or older may be included (e.g., in a study with individuals 45-90 where data are presented for three age groups: 45-55, 55-65, and 65-90, only data for 65-90 may be included)
Health Status of Study Subjects	**Include:** • Pre-sarcopenic Individuals • Pre-frail Individuals	• No restriction will be applied to participants' setting or health status (e.g., obstructive pulmonary disorder, cognitive impairments, cardiovascular disease, Parkinson's disease, post-hip fracture, stroke, visual impairment)
Exposure/ Intervention	**Include:** • All types and intensities of physical activity **Exclude:** • Studies of multimodal interventions that do not present data on physical activity alone • Studies that only use physical activity as a confound variable	
Comparison	**Include:** • No physical activity or lesser volume, duration, frequency, or intensity of physical activity.	
Outcome	**Include:** • Measures of sarcopenia • Measures of frailty	Authors need to specify that sarcopenia/frailty was the outcome of interest. We will accept the authors' definition of sarcopenia/frailty.

APPENDIX 2. Search strategy

Database: PubMed; Date of Search: 06/11/2019; Results: 191

Description	Search terms*
Limit: language and exclude animal only	(English[lang]) NOT ("Animals"[Mesh] NOT ("Animals"[Mesh] AND "Humans"[Mesh]))
Limit: age groups	NOT (("infant"[Mesh] OR "child"[mesh] OR "adolescent"[mh]) NOT (("infant"[Mesh] OR "child"[mesh] OR "adolescent"[mh]) AND "adult"[Mesh]))
Limit: date	AND ("2008/01/01"[PDAT] : "3000/12/31"[PDAT])
Publication type	AND (systematic[sb] OR meta-analysis[pt] OR "systematic review"[tiab] OR "systematic literature review"[tiab] OR metaanalysis[tiab] OR "meta analysis"[tiab] OR metanalyses[tiab] OR "meta analyses"[tiab] OR "pooled analysis"[tiab] OR "pooled analyses"[tiab] OR "pooled data"[tiab])
Limit: publication type	NOT ("comment"[Publication Type] OR "editorial"[Publication Type])
Physical activity	AND (("Exercise"[mh] OR "Exercise"[tiab] OR "Physical activity"[tiab] OR "Sedentary behavior"[mh] OR "Lifestyle activities"[tiab] OR "Lifestyle activity"[tiab] OR "Recreational activities"[tiab] OR "Recreational activity"[tiab] OR "Tai ji"[mh] OR "Yoga"[mh] OR "Activities of daily living"[tiab] OR "Activity of daily living"[tiab] OR "Free living activities"[tiab] OR "Free living activity"[tiab] OR "Balance training"[tiab] OR "Qigong"[mh] OR "Functional training"[tiab]) OR (("Aerobic activities"[tiab] OR "Aerobic activity"[tiab] OR "Cardiovascular activities"[tiab] OR "Cardiovascular activity"[tiab] OR "Endurance activities"[tiab] OR "Endurance activity"[tiab] OR "Physical activities"[tiab] OR "Physical conditioning"[tiab] OR "Resistance training"[tiab] OR "strength training"[tiab] OR "Sedentary"[tiab] OR "Tai chi"[tiab] OR "Tai ji"[tiab] OR "Yoga"[tiab] OR "Walk"[tiab] OR "Walking"[tiab] OR "Chi kung"[tiab] OR "Qigong"[tiab] OR "stretching"[tiab]) NOT medline[sb]))
Osteoporosis	AND ("Sarcopenia"[mh] OR "Frailty"[mh] OR "Frail Elderly"[mh] OR "Sarcopenia"[tiab] OR "Frailty"[tiab] OR "Frailties"[tiab] OR "Frailness"[tiab] OR "Frailty Syndrome"[tiab] OR "Frail Elderly"[tiab] OR "Frail Elders"[tiab] OR "Frail Elder"[tiab] OR "Functionally-Impaired Elderly"[tiab] OR "Functionally Impaired Elderly"[tiab] OR "Frail Older Adults"[tiab] OR "Frail Older Adult"[tiab])

*Search strategy created by WHO

APPENDIX 3. Categories of physical activity programmes (ProFaNE): definitions and application

Physical activity category	ProFaNE description	How the category criteria were applied in this review[a]
Gait, balance, and functional training	Gait training involves specific correction of walking technique (e.g., posture, stride length and cadence) and changes of pace, level and direction. Balance training involves the efficient transfer of bodyweight from one part of the body to another or challenges specific aspects of the balance systems (e.g., vestibular systems). Balance retraining activities range from the re-education of basic functional movement patterns to a wide variety of dynamic activities that target more sophisticated aspects of balance. Functional training uses functional activities as the training stimulus, and is based on the theoretical concept of task specificity. All gait, balance and functional training should be based on an assessment of the participant's abilities prior to starting the programme; tailoring of the intervention to the individual's abilities; and progression of the exercise programme as ability improves	Selected as exercise category if the intervention met the baseline assessment, tailoring and progression criteria. Selected as primary category for interventions where most exercises were conducted standing and where the intervention focus and most time spent was on exercise in this category
Strength/resistance (including power)	The term 'resistance training' covers all types of weight training i.e., contracting the muscles against a resistance to 'overload' and bring about a training effect in the muscular system. The resistance is an external force, which can be one's own body placed in an unusual relationship to gravity (e.g., prone back extension) or an external resistance (e.g., free weight). All strength/resistance training should be	Selected as exercise category if the intervention met the baseline assessment, tailoring and progression criteria. Selected as primary category for interventions where additional resistance was used or where it was clear that overload was sufficient without external

	based on an assessment of the participant's abilities prior to starting the programme; tailoring the intervention to the individual's abilities; and progression of the exercise programme as ability improves	resistance and where the intervention focus and most time spent was on exercise in this category
Flexibility	Flexibility training is the planned process by which stretching exercises are practised and progressed to restore or maintain the optimal range of movement (ROM) available to a joint or joints. The ranges of motion used by flexibility programmes may vary from restoration/maintenance of the entire physiological range of motion, or alternatively, maintenance of range that is essential to mobility or other functions	Selected as exercise category if the intervention met the progression of stretching criterion. Selected as primary category for interventions where flexibility training was a stated aim of the intervention and where the intervention focus and most time spent was on exercise in this category
3D	3D training involves constant movement in a controlled, fluid, repetitive way through all three spatial planes or dimensions (forward and back, side to side, and up and down). Tai Chi and Qi Gong incorporate specific weight transferences and require upright posture and subtle changes of head position and gaze direction. Dance involves a wide range of dynamic movement qualities, speeds and patterns	Selected as exercise category if the intervention involved Tai Chi or dance. Selected as primary category for interventions where the intervention focus and most time spent was on exercise in this category
General physical activity	Physical activity is any bodily movement produced by skeletal muscle contraction resulting in a substantial increase in energy expenditure. Physical activity has both occupational, transportation and recreational components and includes pursuits like golf, tennis, and swimming. It also includes other active pastimes like gardening, cutting wood, and	Selected as exercise category if the intervention included unstructured physical activity. We classed programmes that included unstructured walking as this category. Selected as primary category for interventions where the intervention focus and most

	carpentry. Physical activity can provide progressive health benefits and is a catalyst for improving health attitudes, health habits, and lifestyle. Increasing habitual physical activity should be with specific recommendations as to duration, frequency and intensity if a physical or mental health improvement is indicated	time spent was on exercise in this category
Endurance	Endurance training is aimed at cardiovascular conditioning and is aerobic in nature and simultaneously increases the heart rate and the return of blood to the heart	Selected as exercise category if the intervention focused on structured aerobic training. We classed programmes that included treadmill walking as this category. Selected as primary category for interventions where the intervention focus and most time spent was on exercise in this category
Other	Other kinds of exercises not described	Selected as exercise category if the intervention did not meet the other categories listed and where the intervention focus and most time spent was on exercise in this category
[a]Interventions were allocated a secondary category if some but not all criteria were met by the intervention or where the category was not the primary focus of the intervention, or both		

APPENDIX 4. Criteria used to apply the GRADE framework

The GRADE system classifies the evidence in one of four levels:

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect. Further research is very unlikely to change our confidence in the estimate of effect

Moderate certainty: We are moderately confident in the effect estimate. The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different. Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate

Low certainty: Our confidence in the effect estimate is limited. The true effect may be substantially different from the estimate of the effect. Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate

Very low certainty: We have very little confidence in the effect estimate. The true effect is likely to be substantially different from the estimate of effect. Any estimate of effect is very uncertain.

Evidence based on **randomised controlled*** trials begins as high quality evidence, but our confidence in the evidence may be decreased for:	
Study limitations	We considered the methodological quality of the included studies. We downgraded the evidence if > 50% of included trials had a PEDro score** <6/10 (RCT)*(23)* or > 25% of the included studies with high risk of bias (observational studies)
Imprecision	We considered the sample size and number of included studies. We downgraded the evidence if total number of participants was less than 400 across all studies*(23)* or if there was only one study.
Inconsistency of results	We considered the heterogeneity of included studies in terms of direction of effect. We downgraded the evidence if < 75% of effects were in the same direction.
Indirectness of evidence	Since we only included similar studies in terms of population, intervention, comparator and outcome, we did not downgrade the evidence based on this criteria.
Publication bias	In the absence of a funnel plot to assess publication bias we looked at the number of small studies (n<50) published that found significant effects. We planned to downgrade the evidence if all small studies found significant effects but were often unable to assess this due to the small number of studies.

* The evidence based on observational studies starts as low quality. For observational studies, only evidence from studies with no important threats to validity should be upgraded.

**PEDro scale was used to assess the methodological quality of included RCTs. An adapted version of the Quality in Prognosis Studies (QUIPS) tool was used for the observational study.

APPENDIX 5. Reasons for exclusion at full text screening for existing systematic reviews and meta-analysis

Citation	Study type	Population (age <65 years)	Population (frailty/sarcopenia) at study entry	Intervention	Outcome
Antoniak AE, Greig CA. The effect of combined resistance exercise training and vitamin D3 supplementation on musculoskeletal health and function in older adults: a systematic review and meta-analysis. *BMJ open* 2017; 7(7):e014619.				x	
* Apostolo J, Cooke R, Bobrowicz-Campos E, et al. Effectiveness of interventions to prevent pre-frailty and frailty progression in older adults: a systematic review. *JBI database of systematic reviews and implementation reports* 2018; 16(1):140-232.			x	x	
Beaudart C, Dawson A, Shaw SC, et al. Nutrition and physical activity in the prevention and treatment of sarcopenia: systematic review. *Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA* 2017;28(6):1817-33.		x		x	
Burton E, Farrier K, Galvin R, et al. Physical activity programmes for older people in the community receiving home care services: systematic review and meta-analysis. *Clinical interventions in aging* 2019; 14:1045-64.					x
Chang PS, Knobf T, Oh B, et al. Physical and Psychological Health Outcomes of Qigong Exercise in Older Adults: A Systematic Review and Meta-Analysis. *The American journal of Chinese medicine* 2019; 47(2):301-22.					x

Csapo R, Alegre LM. Effects of resistance training with moderate vs heavy loads on muscle mass and strength in the elderly: A meta-analysis. *Scandinavian journal of medicine & science in sports* 2016; 26(9):995-1006.		x			x
da Rosa Orssatto LB, de la Rocha Freitas C, Shield AJ, et al. Effects of resistance training concentric velocity on older adults' functional capacity: A systematic review and meta-analysis of randomised trials. *Experimental gerontology* 2019; 127:110731.					x
Dedeyne L, Deschodt M, Verschueren S, et al. Effects of multi-domain interventions in (pre)frail elderly on frailty, functional, and cognitive status: a systematic review. *Clinical interventions in aging* 2017; 12:873-96.				x	
* Frost R, Belk C, Jovicic A, et al. Health promotion interventions for community-dwelling older people with mild or pre-frailty: a systematic review and meta-analysis. *BMC geriatrics* 2017; 17(1):157.			x		x
Gordt K, Gerhardy T, Najafi B, et al. Effects of Wearable Sensor-Based Balance and Gait Training on Balance, Gait, and Functional Performance in Healthy and Patient Populations: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Gerontology* 2018; 64(1):74-89.		x		x	
Kidd T, Mold F, Jones C, et al. What are the most effective interventions to improve physical performance in pre-frail and frail adults? A systematic review of randomised control trials. *BMC geriatrics* 2019; 19(1):184.			x		
Lee J, Kim D, Kim C. Resistance Training for Glycemic Control,		x			

Muscular Strength, and Lean Body Mass in Old Type 2 Diabetic Patients: A Meta-Analysis. *Diabetes therapy: research, treatment and education of diabetes and related disorders* 2017; 8(3):459-73.					
*Lee SY, Tung HH, Liu CY, et al. Physical Activity and Sarcopenia in the Geriatric Population: A Systematic Review. *Journal of the American Medical Directors Association* 2018; 19(5):378-83.	x	x			
Liao CD, Chen HC, Kuo YC, et al. Effects of muscle strength training on muscle mass gain and hypertrophy in older adults with osteoarthritis: A systematic review and meta-analysis. *Arthritis care & research* 2019		x			
Liao CD, Lee PH, Hsiao DJ, et al. Effects of Protein Supplementation Combined with Exercise Intervention on Frailty Indices, Body Composition, and Physical Function in Frail Older Adults. *Nutrients* 2018;10(12)				x	
Liao CD, Tsauo JY, Wu YT, et al. Effects of protein supplementation combined with resistance exercise on body composition and physical function in older adults: a systematic review and meta-analysis. *The American journal of clinical nutrition* 2017; 106(4):1078-91.				x	
Liberman K, Forti LN, Beyer I, et al. The effects of exercise on muscle strength, body composition, physical functioning and the inflammatory profile of older adults: a systematic review. *Current opinion in clinical nutrition and metabolic care* 2017; 20(1):30-53. doi: 10.1097/mco.0000000000000335 [published Online First: 2016/10/19]			x		
Lopez P, Izquierdo M, Radaelli R, et al. Effectiveness of Multimodal Training on Functional Capacity in		x	x		x

Frail Older People: A Meta-Analysis of Randomized Controlled Trials. *Journal of aging and physical activity* 2018; 26(3):407-18.					
Luo D, Lin Z, Li S, et al. Effect of nutritional supplement combined with exercise intervention on sarcopenia in the elderly: A meta-analysis. *International journal of nursing sciences* 2017; 4(4):389-401.		x		x	
McKendry J, Breen L, Shad BJ, et al. Muscle morphology and performance in master athletes: A systematic review and meta-analyses. *Ageing research reviews* 2018; 45:62-82.			x		
Milder DA, Pillinger NL, Kam PCA. The role of rehabilitation in frail surgical patients: A systematic review. *Acta anaesthesiologica Scandinavica* 2018; 62(10):1356-66.					x
Negm AM, Kennedy CC, Thabane L, et al. Management of frailty: a protocol of a network meta-analysis of randomized controlled trials. *Systematic reviews* 2017; 6(1):130.	x				
Negm AM, Kennedy CC, Thabane L, et al. Management of Frailty: A Systematic Review and Network Meta-analysis of Randomized Controlled Trials. *Journal of the American Medical Directors Association* 2019;20(10):1190-98			x		
Peterson MD, Rhea MR, Sen A, et al. Resistance exercise for muscular strength in older adults: a meta-analysis. *Ageing research reviews* 2010; 9(3):226-37.		x			
* Peterson MD, Sen A, Gordon PM. Influence of resistance exercise on lean body mass in aging adults: a meta-analysis. *Medicine and science in sports and exercise* 2011;43(2):249-58		x			

Poggiogalle E, Migliaccio S, Lenzi A, et al. Treatment of body composition changes in obese and overweight older adults: insight into the phenotype of sarcopenic obesity. *Endocrine* 2014; 47(3):699-716.		x			
Sardeli AV, Komatsu TR, Mori MA, et al. Resistance Training Prevents Muscle Loss Induced by Caloric Restriction in Obese Elderly Individuals: A Systematic Review and Meta-Analysis. *Nutrients* 2018;10(4)		x			
*Steffl M, Bohannon RW, Sontakova L, et al. Relationship between sarcopenia and physical activity in older people: a systematic review and meta-analysis. *Clinical interventions in aging* 2017; 12:835-45.	x				
* Stewart VH, Saunders DH, Greig CA. Responsiveness of muscle size and strength to physical training in very elderly people: a systematic review. *Scandinavian journal of medicine & science in sports* 2014; 24(1):e1-10.			x		
* Travers J, Romero-Ortuno R, Bailey J, et al. Delaying and reversing frailty: a systematic review of primary care interventions. *The British journal of general practice: the journal of the Royal College of General Practitioners* 2019; 69(678):e61-e69.				x	
Trethewey SP, Brown N, Gao F, et al. Interventions for the management and prevention of sarcopenia in the critically ill: A systematic review. *Journal of critical care* 2019; 50:287-95.		x	x		
Weening-Dijksterhuis E, de Greef MH, Scherder EJ, et al. Frail institutionalized older persons: A comprehensive review on physical exercise, physical fitness, activities of daily living, and quality-of-life. *American journal of physical*			x		

medicine & rehabilitation 2011; 90(2):156-68.					
Windle G, Hughes D, Linck P, et al. Is exercise effective in promoting mental well-being in older age? A systematic review. *Aging & mental health* 2010; 14(6):652-69.					x
* Zheng L, Li G, Wang X, et al. Effect of exergames on physical outcomes in frail elderly: a systematic review. *Aging clinical and experimental research* 2019					x

*indicates reviews that were excluded, but included studies that are relevant to the present review.

APPENDIX 6. Methodological quality of included studies

Study	PEDro Scale Items[a]											PEDro Score (0 to 10)
	1[b]	2	3	4	5	6	7	8	9	10	11	
Goodpaster et al. (2008)	N	Y	N	Y	N	N	Y	N	N	Y	Y	5
Henwood et al. (2008)	Y	Y	N	Y	N	N	N	N	N	Y	Y	4
Kemmler et al. (2013)	Y	Y	N	Y	N	N	Y	N	Y	Y	Y	6
Lustosa et al. (2011)	Y	Y	N	Y	N	N	Y	Y	N	Y	Y	6
Oh et al. (2017)	Y	Y	N	Y	N	N	N	N	N	Y	Y	4
Santos et al. (2018)	Y	Y	N	N	N	N	N	N	N	Y	Y	3
Serra-Prat et al. (2017)	Y	Y	Y	Y	N	N	N	N	N	Y	Y	5
Wolf et al. (2003)	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5
Yu et al. (2014)	NA											

Y = yes, N = no. [a] 1 = Eligibility criteria and source of participants, 2 = random allocation, 3 = concealed allocation, 4 = baseline comparability, 5 = blinded participants, 6 = blinded therapists, 7 = blinded assessors, 8 = adequate follow-up, 9 = intention-to-treat analysis, 10 = between-group comparisons, 11 = point estimates and variability. [b] Item 1 does not contribute to the total score. NA: not applicable as the study is an observational study.

APPENDIX 7. Quality in Prognosis Studies (QUIPS) tool used to assess risk of bias of one observational study

Domain and Prompting items for Consideration	Ratings	Risk of bias score
Study Participation a. Adequate participation in the study by eligible persons b. Description of the source population or population of interest c. Description of the baseline study sample d. Adequate description of the sampling frame and recruitment e. Adequate description of the period and place of recruitment f. Adequate description of inclusion and exclusion criteria	**High bias:** > 2 items poorly rated **Low bias**: ≤ 2 items poorly rated	Low risk
Study Attrition a. Adequate response rate for study participants b. Description of attempts to collect information on participants who dropped out c. Reasons for loss to follow-up are provided d. Adequate description of participants lost to follow-up e. There are no important differences between participants who completed the study and those who did not	**High bias:** > 2 items poorly rated **Low bias**: ≤ 2 items poorly rated	High risk

Exposure Measurement: Measures of physical activity		
a. A clear definition or description of physical activity is provided b. Method of physical activity measurement is adequately valid and reliable c. The method and setting of measurement of physical activity is the same for all study participants d. Adequate proportion of the study sample has complete data for the physical activity e. Appropriate methods of imputation are used	**High bias:** > 2 items poorly rated **Low bias**: ≤ 2 items poorly rated	Low risk
Outcome Measurement: Measures of sarcopenia		
a. A clear definition of the outcome is provided b. Method of outcome measurement used is adequately valid and reliable c. The method and setting of outcome measurement is the same for all study participants	**High bias:** > 2 items poorly rated **Low bias**: ≤ 2 items poorly rated	Low risk
Adjusted for confounders		
a. Important confounders are measured b. Measurement of important confounders is adequately valid and reliable c. The method and setting of confounding measurement are the same for all study participants d. Appropriate methods are used if imputation is used for missing confounder data e. Important potential confounders are accounted for in the study design f. Important potential confounders are accounted for in the analysis	**High bias:** <3 relevant confounders were included in the adjusted models. **Low bias:** ≥3 relevant confounders were included in the adjusted models.	Low risk

Statistical Analysis and Reporting a. Sufficient presentation of data to assess the adequacy of the analysis b. Strategy for model building is appropriate and is based on a conceptual framework or model c. The selected statistical model is adequate for the design of the study d. There is no selective reporting of results	**High bias:** > 2 items poorly rated **Low bias**: ≤ 2 items poorly rated	Low risk
Overall Rating: Low risk of bias *Low Risk of Bias: Low risk of bias on at least four of the seven domains including study confounding.*		

APPENDIX 8. Level of evidence according to the GRADE approach: Exercise on frailty outcome

The GRADE approach was applied to one randomised controlled trial. The quality of evidence starts as high for RCTs. We downgraded to low due to risk of bias and the single study.

Overall result: Physical activity may prevent frailty in older adults	
Level of evidence: Low certainty Our confidence in the results is limited. The true effect may be substantially different from the estimate of the effect. Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.	
Study limitations	We downgraded the evidence by one level as the RCT had a PEDro score <6/10.
Imprecision	We downgraded the evidence by one level as there was a single study.
Inconsistency of results	Not applicable.
Indirectness of evidence	Not applicable.
Publication bias	We did not downgrade the evidence for publication bias as there were too few studies to assess publication bias.

APPENDIX 9. Level of evidence according to the GRADE approach: Exercise on sarcopenia outcome

The GRADE approach was applied to one longitudinal study. The quality of evidence starts as low for observational studies. We downgraded to very low as there was only one study.

Overall result: We are uncertain whether physical activity prevents sarcopenia (as the certainty of the evidence has been assessed as very low).	
Level of evidence: Very low certainty We have very little confidence in the effect estimate. The true effect is likely to be substantially different from the estimate of effect. Any estimate of effect is very uncertain.	
Study limitations	We did not downgrade the evidence as the observational study was assessed as having a low risk of bias.
Imprecision	We downgraded the evidence by one level as there was only one study.
Inconsistency of results	Not applicable.
Indirectness of evidence	Not applicable.
Publication bias	We did not downgrade the evidence for publication bias as there were too few studies to assess publication bias.

APPENDIX 10. Level of evidence according to the GRADE approach: Exercise vs control on frailty-related outcomes

The GRADE approach was applied to four randomised controlled trials comparing physical activity with control on frailty-related outcomes. Since some studies included more than one intervention group and outcome measure, there were 18 relevant comparisons between physical activity and control groups.

Overall result: Physical activity may prevent frailty-related outcomes in older adults.	
Level of evidence: Low certainty Our confidence in the results is limited. The true effect may be substantially different from the estimate of the effect. Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.	
Study limitations	We downgraded the evidence by one level as 3/4 studies (75%) had a PEDro score <6/10.
Imprecision	The 4 included studies had a total of 326 participants analysed. Therefore, we downgraded the evidence.
Inconsistency of results	We did not downgrade the evidence due to heterogeneity of included studies as most comparisons (16/18) showed a positive effect.
Indirectness of evidence	Since we only included similar studies in terms of population, intervention, comparator and outcome, we did not downgrade the evidence based on this criterion.
Publication bias	We did not downgrade the evidence for publication bias as there were too few studies to assess publication bias.

APPENDIX 11. Level of evidence according to the GRADE approach: Exercise vs control on sarcopenia-related outcomes

The GRADE approach was applied to two randomised controlled trials comparing physical activity with control on sarcopenia-related outcomes. Since some studies included more than one intervention group and outcome measure, there were four relevant comparisons between physical activity and control groups.

Overall result: Physical activity may prevent frailty-related outcomes in older adults.	
Level of evidence: Low certainty Our confidence in the results is limited. The true effect may be substantially different from the estimate of the effect. Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.	
Study limitations	We downgraded the evidence by one level as 1/2 studies (50%) had a PEDro score <6/10.
Imprecision	The two included studies had a total of 204 participants analysed. Therefore, we downgraded the evidence.
Inconsistency of results	We did not downgrade the evidence due to heterogeneity of included studies as all studies (4/4) showed a positive effect for exercise.
Indirectness of evidence	Since we only included similar studies in terms of population, intervention, comparator and outcome, we did not downgrade the evidence based on this criterion.
Publication bias	We did not downgrade the evidence for publication bias as there were too few studies to assess publication bias.

APPENDIX 12. Abstracts of included studies

<table>
<tr><td colspan="2">Study design: RCT

Citation: Goodpaster BH, Chomentowski P, Ward BK, Rossi A, Glynn NW, Delmonico MJ, Kritchevsky SB, Pahor M, Newman AB. Effect of physical activity on strength and skeletal muscle fat infiltration in older adults: a randomized controlled trial. J Appl Physiol. 2008; 105:1498-1503</td></tr>
<tr><td>Purpose: whether increased physical activity could prevent or reverse the losses of strength and skeletal muscle mass as well as the gain in fat in older adults</td><td rowspan="6">Abstract:

Considerable evidence suggests that the loss of strength and muscle mass appear to be inevitable consequences of aging. Moreover, aging is associated with an increase in body fat. This study examined whether increased physical activity could prevent or reverse the losses of strength and skeletal muscle mass as well as the gain in fat in older adults. Eleven men and 31 women completed a randomized trial consisting of either a physical activity (PA; n = 22) or successful aging health educational control (SA; n = 20) group. Isokinetic knee extensor strength and computed tomography-derived midthigh skeletal muscle and adipose tissue cross-sectional areas (CSA) were assessed at baseline and at 12 mo following randomization. Total body weight and muscle CSA decreased in both groups, but these losses were not different between groups. Strength adjusted for muscle mass decreased (-20.1 ± 9.3%, $P < 0.05$) in SA. The loss of strength was completely prevented in PA (+2.5 ± 8.3%). In addition, there was a significant increase (18.4 ± 6.0%) in muscle fat infiltration in SA, but this gain was nearly completely prevented in PA (2.3 ± 5.7%). In conclusion, regular physical activity prevents both the age-associated loss of muscle strength and increase in muscle fat infiltration in older adults with moderate functional limitations.</td></tr>
<tr><td>Follow-up duration: 12 months</td></tr>
<tr><td>Total # participants included: 42</td></tr>
<tr><td>Participants with pre-frailty/pre-sarcopenia at baseline: No</td></tr>
<tr><td>PEDro score: 5/10</td></tr>
<tr><td>Outcomes addressed: knee extensor strength measured with Kin-Com dynamometer and thigh muscle measured with axial CT scan</td></tr>
</table>

<table>
<tr><td colspan="2">Study design:

Citation: Henwood TR, Stephan R, Taaffe DR. Strength Versus Muscle Power-Specific Resistance Training in Community-Dwelling Older Adults. Journal of Gerontology. 2008;63A(1):83-91</td></tr>
<tr><td>Purpose: To compare two resistance training programmes, one aimed at enhancing muscle power and one at increasing muscle strength, on muscle function and functional performance in older adults.</td><td rowspan="6">Abstract:

Background. Loss of muscle power due to normal aging has greater functional impact than loss of strength alone. The present study compared two resistance training programmes, one aimed at enhancing muscle power and one at increasing muscle strength, on muscle function and functional performance in older adults.

Methods. Sixty-seven healthy, independent older adults (65–84 years) were randomized to a high-velocity varied resistance (HV), constant resistance (ST), or nontraining control (CO) group. Participants trained twice weekly for 24weeks using six exercises. Dynamic and isometric muscle strength, muscle power, movement velocity, muscle endurance, and a battery of functional performance tasks were assessed. Secondary outcomes included body composition, quality of life, and balance confidence.

Results. Muscle strength increased significantly (p < .001) and similarly in the training groups compared to controls (HV, 51.0 ± 9.0%; ST, 48.3 ± 6.8%; CO, 1.2 ± 5.1%). Peak muscle power also increased with training (p < .05), with no difference between training groups. The change in peak power was 50.5 ± 4.1%, 33.8 ± 3.8%, and -2.5 ± 3.9% in the HV, ST, and CO groups, respectively. Training also improved selected functional performance tasks in the HV and ST groups compared to controls (p < .05), and the HV group reported improved quality of life (p = .018).

Conclusion. Muscle power and muscle strength improved similarly using either resistance training protocol, and these changes were accompanied by improvements in several functional performance tasks. However, improvements in the HV group occurred with less total work performed per training session.

Key Words: Resistance training—Muscle power—Movement velocity—Functional performance—Muscle strength.</td></tr>
<tr><td>Follow-up duration: 24 weeks</td></tr>
<tr><td>Total # participants included: 67</td></tr>
<tr><td>Participants with pre-frailty/pre-sarcopenia at baseline: No</td></tr>
<tr><td>PEDro score: 4/10</td></tr>
<tr><td>Outcomes addressed: Dynamic muscle strength and muscle endurance measured with 1RM method. Functional performance measured with usual 6-m walk; repeated chair rise to standing (5 times). Lean body mass assessed with dual-energy x-ray absorptiometry (DXA) technique</td></tr>
</table>

<table>
<tr><td colspan="2">Study design:
Citation: Kemmler W, von Stengel S. Exercise Frequency, Health Risk Factors, and Diseases of the Elderly. Archives of Physical Medicine and Rehabilitation. 2013;94:2046-2053</td></tr>
<tr><td>Purpose: To determine the effect of exercise frequency on various diseases and risk factors of the elderly.

Follow-up duration: 18 months

Total # participants included: 162

Participants with pre-frailty/pre-sarcopenia at baseline: 0

PEDro score: 6/10

Outcomes addressed: Lean body mass (LBM) and appendicular skeletal muscle mass (ASMM) assessed with dual-energy x-ray absorptiometry (DXA) technique</td><td>Abstract:
Objective: To determine the effect of exercise frequency on various diseases and risk factors of the elderly.
Design: Retrospective analysis of a randomized controlled 18-month exercise trial.
Setting: University ambulatory group setting.
Participants: Community-dwelling women aged ≥65 years (N=162) in the area of Northern Bavaria.
Intervention: Mixed, intense aerobic, resistance, and balance protocol for 18 months. Subjects were retrospectively subdivided into 2 groups according to their effective attendance over 18 months (>1-<2 vs ≥2-4 sessions/wk).
Main Outcome Measures: Bone mineral density (BMD), lean body mass, appendicular skeletal muscle mass by dual-energy x-ray absorptiometry, Framingham study-based 10-year coronary heart disease (CHD) risk, and number of falls by calendar method.
Results: Significant differences between the low-frequency exercise group (LF-EG) and the high-frequency exercise group (HF-EG) were observed for lumbar spine BMD (HF-EG, 2.4%±2.8% vs LF-EG, 0.3%±2.2%; P<.001) and proximal femur BMD (HF-EG, 2.4%_2.8% vs LF-EG, -0.5%±1.6%; P=.014), lean body mass (1.6%±3.4% vs 0.3%±2.6%, P=.053), and appendicular skeletal muscle mass (0.9%±4.5% vs -1.3%±3.2%, P=.011). No differences between both exercise groups were observed for 10-year CHD risk (-1.94%±4.14% vs -2.00%±3.13%; P=.943) and number of falls (0.95±1.36 vs 1.03±1.21 falls/person). Comparing the LF-EG with the less active control group (n=47), only nonsignificant effects for fall number (P=.065) and 10-year CHD risk (P=.178) were evaluated.
Conclusions: Although this result might not be generalizable across all exercise types and cohorts, it indicates that an overall exercise frequency of at least 2 sessions/wk may be crucial for impacting bone and muscle mass of elderly subjects.</td></tr>
</table>

Study design:

Citation: Lustosa LP, Silva JP, Coelho FM, Pereira DS, Parentoni AN, Pereira LSM. Impact of resistance exercise program on functional capacity and muscular strength of knee extensor in pre-frail community-dwelling older women: a randomized crossover trial. *Rev Bras Fisioter.* 2011;15(4):318-324

Purpose: to verify the effect of a muscle-strengthening program with load in pre-frail elder women with regards to the functional capacity, knee extensor muscle strength and their correlation.

Follow-up duration: 10 weeks

Total # participants included: 32

Participants with pre-frailty/pre-sarcopenia at baseline: Yes

PEDro score: 6/10

Outcomes addressed: Knee extensors muscle strength assessed by isokinetic dynamometer Byodex System 3 Pro@ at 600/s. Functional performance assessed by Timed up and go (TUG), the 10-meter walk test (10MWT) and sitting-rising test (SRT).

Abstract:

Background: Frailty syndrome in elderly people is characterized by a reduction of energy reserves and also by a decreased of resistance to stressors, resulting in an increase of vulnerability.

Objective: The aim of this study was to verify the effect of a muscle-strengthening program with load in pre-frail elder women with regards to the functional capacity, knee extensor muscle strength and their correlation.

Methods: Thirty-two pre-frail community-dwelling women participated in this study. Potential participants with cognitive impairment (MEEM), lower extremities orthopedic surgery, fractures, inability to walk unaided, neurological diseases, acute inflammatory disease, tumor growth, regular physical activity and current use of immunomodulators were excluded. All partcipants were evaluated by a blinded assessor using: Timed up and go (TUG), 10-Meter Walk Test (10MWT) and knee extensor muscle strength (*Byodex System 3 Pro□* isokinetic dynamometer at angular speeds of 60 and 1800/s). The intervention consisted of strengthening exercises of the lower extremities at 70% of 1RM, three times/week for ten weeks. The statistical analysis was performed using the ANOVA and Spearman tests.

Results: After the intervention, it was observed statistical significance on the work at 1800/s (F=12.71, p=0.02), on the power at 1800/s (F=15.40, p=0.02) and on the functional capacity (TUG, F=9.54, p=0.01; TC10, F=3.80, p=0.01). There was a good negative and statistically significant correlation between the TUG and work at 600/s, such as the TUG and work at 1800/s (r=-0.65, p=0.01; r=-0.72, p=0.01).

Conclusion: the intervention improved the muscular power and the functional capacity. The increase of the power correlated with function, which is an important variable of the quality of life in the pre-frail elders.

Keywords: physical therapy; rehabilitation; elderly; functional performance; muscle strength.

<table>
<tr><td colspan="2">Study design:

Citation: Oh SL, Kim HJ, Woo S, Cho BL, Song, M, Park YH, Lim JY, Song W. Effects of an integrated health education and elastic band resistance training program on physical function and muscle strength in community-dwelling elderly women: Healthy Aging and Happy Aging II Study. Geriatr Gerontol Int. 2017;17:825-833</td></tr>
<tr><td>Purpose: the effect of an integrated health education and elastic band resistance training program on body composition, physical function, muscle strength and quality in community-dwelling elderly women.</td><td rowspan="6">Abstract:

Aim: In the present study, we determined the effect of an integrated health education and elastic band resistance training program on body composition, physical function, muscle strength and quality in community-dwelling elderly women.

Methods: We recruited participants with eligibility inclusion criteria, and randomly assigned them to either the control group (n= 19) or the intervention group (n= 19). The integrated intervention program comprised of health education and individual counselling, and elastic band training for 18weeks (8weeks of supervised training and 10weeks of self-directed training).We assessed body composition, muscle strength and quality, and physical function at pre-, after 8weeks (mid-) and 18weeks (post-training).

Results: After the intervention, there were no significant changes in skeletal muscle index, fat free mass, total lean mass and total fat mass for both the control group and intervention group. However, the interaction effect was significantly different in SPPB score (P<0.05), isokinetic strength (60 deg/s, P<0.001; 120 deg/s; P<0.05) and muscle quality (P<0.05) after 18weeks of intervention relative to the baseline of the control and intervention groups. The supervised elastic band training of 8weeks did not improve short physical performance battery score and isokinetic strength, whereas there was a significant increase of those outcomes (10.6% improvement, 9.8~23.5% improvement) after 10weeks of following self-directed exercise compared with the baseline.

Conclusions: These results show the effectiveness of following self-directed resistance training with health education after supervised training cessation in improvement of short physical performance battery and leg muscle strength. This intervention program might be an effective method to promote muscle strength and quality, and to prevent frailty in elderly women.</td></tr>
<tr><td>Follow-up duration: 18 weeks</td></tr>
<tr><td>Total # participants included: 38</td></tr>
<tr><td>Participants with pre-frailty/pre-sarcopenia at baseline: No</td></tr>
<tr><td>PEDro score: 4/10</td></tr>
<tr><td>Outcomes addressed: knee extensor measured with isokinetic dynamometer at 600/s. Physical function assessed using SPPB. Skeletal muscle index assessed using dual-energy X-ray absorptiometry (DXA)</td></tr>
</table>

Study design:	
Citation: Santos GOR, Wolf R, Silva MM, Rodacki ALF, Pereira G. Does exercise intensity increment in exergame promote changes in strength, functional capacity and perceptual parameters in pre-frail older women? A randomized controlled trial. *Experimental Gerontoloty.* 2019;116:25-30	
Purpose: to compare the effects of two exercise intensities on exergame training program in muscle strength, functional capacity and perceptual parameters in pre-frail older women.	**Abstract:** The aim of this study was to compare the effects of two exercise intensities on exergame training program in muscle strength, functional capacity and perceptual parameters in pre-frail older women. Thirty-four women (69.5 ± 5.4 years) were randomly assigned to either moderate- (MG: 11–13 perceived exertion) or vigorous exercise intensity group (VG: 14–16 perceived exertion). Muscle strength and functional capacity were evaluated before and after 3 months of training. The affective responses were measured once a week and perceived benefit was evaluated after training period. The MG improved the average power at 60°/s from pre- to post-training ($p < 0.002$) on the knee extensor (pre=100.0 ± 15.9 W; post=115.2 ± 22.6 W), flexor (pre=22.3 ± 6.1 W; post=29.1 ± 7.9 W) and plantiflexor muscles (pre=11.4 ± 5.9 W; post=21.2 ± 4.2 W). MG presented greater average power at post-training than VG for knee extensor (20%) and flexor muscles (23%) ($P < 0.039$). There was main time effect of peak torque at 180°/s for knee extensor (pre=74.15 ± 14.28 N·m/kg; post=81.31 ± 18.4 N·m/kg), flexor (pre=43.01 ± 12.43 N·m/kg; post=48.3 ± 9.11 N·m/kg) and plantiflexor muscles (pre=29.2 ± 13.76 N·m/kg; post=36.87 ± 9.7 N·m/kg) as well as average power (pre=41.15 ± 15.67 W; post=48.42 ± 11.8 W) and work (pre=99.92 ± 38.53 J; post=117.03 ± 25.56 J) on the knee flexor muscles ($p < 0.046$). MG improved timed up and go performance from pre- to post-training (pre=10.0 ± 0.32 s; post=8.1 ± 1.6 s, p=0.001), whereas both groups improved 10 m-walk performance (pre=1.33 ± 0.25 s, post=1.5 ± 0.24 s; p=0.003). Positive affect (2.64 ± 0.02) and pleasure (15.8 ± 0.6) for MG were greater than VG at post-training (2.36 ± 0.03; $p < 0.001$; 14.4 ± 0.5; $p < 0.03$). Therefore, regardless of the exercise intensity, exergame training improved muscle strength and functional capacity in pre-frail older women. However, positive affect and pleasure were reported only when older women practiced exergame with moderate exercise intensity.
Follow-up duration: 3 months	
Total # participants included: 34	
Participants with pre-frailty/pre-sarcopenia at baseline: Yes	
PEDro score: 3/10	
Outcomes addressed: Knee extensor measured with isokinetic dynamometer at 600/s. Functional capacity: measured with sit to stand (STS), timed up and go (TUG) and 10m walk test	

<table>
<tr><td colspan="2">Study design: A randomised, open label, controlled trial with two parallel arms

Citation: Serra-Prat M, Sist X, Domenich R, Jurado L, Saiz A, Roces A, Palomera E, Tarradelles M, Papiol M. Effectiveness of an intervention to prevent frailty in pre-frail community-dwelling older people consulting in primary care: a randomised controlled trial. Age and Ageing. 2017;46:401-407</td></tr>
<tr><td>Purpose: to assess the effect of an intervention in preventing frailty progression in pre-frail older people.

Follow-up duration:

Total # participants included: 172

Participants with pre-frailty/pre-sarcopenia at baseline: Yes

PEDro score: 5/10

Outcomes addressed: Prevalence of frailty assessed with the presence of three or more Fried criteria</td>
<td>Abstract:

Background: evidence on the effectiveness of interventions to prevent frailty is scarce.

Objective: to assess the effect of an intervention in preventing frailty progression in pre-frail older people.

Study design: a randomised, open label, controlled trial with two parallel arms.

Population: community-dwelling pre-frail older people (≥70 years) consulting in primary care.

Intervention: nutritional assessment (and derivation to a Nutritional Unit for usual care in the event of nutritional risk) and a physical activity programme including aerobic exercise and a set of mixed strengthening, balance and coordination exercises

Control group: patients receiving the usual care.

Main outcome measure: prevalence of frailty (Fried criteria) at 12 months.

Secondary outcomes measures: functional capacity (Barthel index), falls and nutritional status (Short-Form Mini Nutritional Assessment) on follow-up at 12 months.

Results: one hundred and seventy-two participants were recruited and randomised (mean age: 78.3 years; mean number of Fried criteria: 1.45). Thirty-nine participants (22.6%) were dropped out during the study. At follow-up, 4.9% of the intervention group and 15.3% of the control group had evolved to frailty, for a crude odds ratio (OR) of 0.29 (95% confidence interval [CI]: 0.08–1.08; P = 0.052) and an adjusted (by age, gender and number of co-morbidities) OR of 0.19 (95% CI: 0.04–0.95; P = 0.044). Intervention group showed a higher outdoors walking hour per day (0.97 versus 0.73; P = 0.019) but no difference was observed in muscle strength, gait speed or other functional indicators.

Conclusion: an intervention focused on physical exercise and maintaining good nutritional status may be effective in preventing frailty in community-dwelling pre-frail older individuals.

Keywords: older people, frailty, physical activity, nutritional status, prevention, functional capacity</td></tr>
</table>

<table>
<tr><td colspan="2">Study design: prospective, randomized, controlled clinical trial with three arms

Citation: Wolf SL, Barnhart HX, Kutner NG, McNeely E, Coogler C, Xu T. Reducing Frailty and Falls in Older Persons: An Investigation of Tai Chi and Computerized Balance Training. J Am Geriatr Soc. 2003;51:1794-1803</td></tr>
<tr><td>Purpose: To evaluate the effects of two exercise approaches, tai chi (TC) and computerized balance training (BT), on specified primary outcomes (biomedical, functional, and psychosocial indicators of frailty) and secondary outcomes (occurrences of fall).</td><td rowspan="6">Abstract:

OBJECTIVES: To evaluate the effects of two exercise approaches, tai chi (TC) and computerized balance training (BT), on specified primary outcomes (biomedical, functional, and psychosocial indicators of frailty) and secondary outcomes (occurrences of fall).

DESIGN: The Atlanta Frailty and Injuries: Cooperative Studies and Intervention Techniques, a prospective, randomized, controlled clinical trial with three arms (TC, BT, and education (ED)). Intervention length was 15 weeks, with primary outcomes measured before and after intervention and at 4-month follow-up. Falls were monitored continuously throughout the study.

SETTING: Persons aged 70 and older living in the community.

PARTICIPANTS: A total of 200 participants, 162 women and 38 men; mean age was 76.2.

MEASUREMENTS: Biomedical (strength, flexibility, cardiovascular endurance, body composition), functional instrumental activities of daily living (IADL), and psychosocial well-being (Center for Epidemiological Studies for Depression scale, fear of falling questionnaire, self-perception of present and future health, mastery index, perceived quality of sleep, and intrusiveness) variables.

RESULTS: Grip strength declined in all groups, and lower extremity range of motion showed limited but statistically significant changes. Lowered blood pressure before and after a 12-minute walk was seen following TC participation. Fear of falling responses and intrusiveness responses were reduced after the TC intervention compared with the ED group (P=.046 and P=.058, respectively). After adjusting for fall risk factors, TC was found to reduce the risk of multiple falls by 47.5%.

CONCLUSION: A moderate TC intervention can impact favorably on defined biomedical and psychosocial indices of frailty. This intervention can also have favorable effects upon the occurrence of falls. TC warrants further study as an exercise treatment to improve the health of older people.</td></tr>
<tr><td>Follow-up duration: 4 month</td></tr>
<tr><td>Total # participants included: 200</td></tr>
<tr><td>Participants with pre-frailty/pre-sarcopenia at baseline: No</td></tr>
<tr><td>PEDro score: 5/10</td></tr>
<tr><td>Outcomes addressed: Indicators of frailty that included: strength assessed using grip strength assessed by the Jamar Smedley-type hand dynamometer. Cardiovascular endurance measured by 12-minute walk</td></tr>
</table>

<table>
<tr><td colspan="2">Study design:

Citation: Yu R, Wong M, Leung J, Lee J, Auyeung TW, Woo J. Incidence, reversibility, risk factors and the protective effect of high body mass index against sarcopenia in community-dwelling older Chinese adults. Geriatr Gerontol Int. 2014;14(1):15-28</td></tr>
<tr><td>Purpose: the incidence and the reversibility of sarcopenia and their associated factors over a 4-year period</td><td rowspan="6">Abstract:

Aim: We examined the incidence and the reversibility of sarcopenia and their associated factors over a 4-year period using the European Working Group on Sarcopenia in Older People (EWGSOP) criteria.

Methods: A total of 4000 community-dwelling older adults aged ≥65 years were evaluated for which detailed information regarding demographics, socioeconomic, medical history, lifestyle, and clinical factors were documented at baseline, 2 years, and 4 years later. Sarcopenia was defined according to the EWGSOP algorithm. Incident sarcopenia and its reversibility were documented at each follow-up year, and related to possible factors.

Results: At baseline, of the 4000 participants, 361 (9.0%) had sarcopenia. Between baseline and 2-year follow-up, 6.0% of the participants without sarcopenia at baseline had developed sarcopenia, and 18.8% of the initially sarcopenic participants had reverted to normal. Between baseline and 4-year follow-up, the corresponding figures were 6.3% and 14.1%, respectively. The average annual incidence over 4 years was 3.1%. After multivariate adjustments, older age, female sex, presence of chronic obstructive pulmonary disease, presence of stroke, higher physical activity levels, presence of instrumental activities of daily living impairments, and lower body mass index were associated with incident sarcopenia, whereas younger age, female sex, higher body mass index and absence of instrumental activities of daily living impairments, but not physical activity, were associated with its reversibility. Protein and vitamin D intake were not significantly associated with sarcopenia incidence or its reversibility.

Conclusion: Sarcopenia incidence increases with age but is potentially reversible in a Chinese elderly population. High body mass index is protective against sarcopenia incidence and its reversibility. Increasing physical activity and maintaining a healthy weight could be beneficial in the prevention of sarcopenia.

Keywords: body mass index, Chinese, elderly, physical activity, sarcopenia.</td></tr>
<tr><td>Follow-up duration: 2 year</td></tr>
<tr><td>Total # participants included: 4000</td></tr>
<tr><td>Participants with pre-frailty/pre-sarcopenia at baseline: Not reported</td></tr>
<tr><td>PEDro score: N/A</td></tr>
<tr><td>Outcomes addressed: Incident sarcopenia.</td></tr>
</table>

REFERENCES

1. Cruz-Jentoft AJ, Sayer AA. Sarcopenia. The Lancet. 2019;393(10191):2636-46.
2. Dent E, Martin FC, Bergman H, Woo J, Romero-Ortuno R, Walston JD. Management of frailty: opportunities, challenges, and future directions. The Lancet. 2019;394(10206):1376-86.
3. Henwood TR, Riek S, Taaffe DR. Strength versus muscle power-specific resistance training in community-dwelling older adults. The journals of gerontology Series A, Biological sciences and medical sciences. 2008;63(1):83-91.
4. Jones DM, Song X, Rockwood K. Operationalizing a Frailty Index from a Standardized Comprehensive Geriatric Assessment. Journal of the American Geriatrics Society. 2004;52(11):1929-33.
5. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. The journals of gerontology Series A, Biological sciences and medical sciences. 2001;56(3):M146-56.
6. Cameron ID, Fairhall N, Langron C, Lockwood K, Monaghan N, Aggar C, et al. A multifactorial interdisciplinary intervention reduces frailty in older people: randomized trial. BMC Medicine. 2013;11(1):65.
7. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age and ageing. 2010;39(4):412-23.
8. Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyere O, Cederholm T, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age and ageing. 2019;48(1):16-31.
9. Cawthon PM, Travison TG, Manini TM, Patel S, Pencina KM, Fielding RA, et al. Establishing the Link Between Lean Mass and Grip Strength Cut-points With Mobility Disability and Other Health Outcomes: Proceedings of the Sarcopenia Definition and Outcomes Consortium Conference. The journals of gerontology Series A, Biological sciences and medical sciences. 2019.
10. Menant JC, Weber F, Lo J, Sturnieks DL, Close JC, Sachdev PS, et al. Strength measures are better than muscle mass measures in predicting health-related outcomes in older people: time to abandon the term sarcopenia? Osteoporosis International. 2017;28(1):59-70.
11. World Health Organization. Global Strategy on Diet, Physical Activity and Health 2010.
12. Lamb SE, Becker C, Gillespie LD, Smith JL, Finnegan S, Potter R, et al. Reporting of complex interventions in clinical trials: development of a taxonomy to classify and describe fall-prevention interventions. Trials. 2011;12:125.
13. Goodpaster BH, Chomentowski P, Ward BK, Rossi A, Glynn NW, Delmonico MJ, et al. Effects of physical activity on strength and skeletal muscle fat infiltration in older adults: a randomized controlled trial. J Appl Physiol (1985). 2008;105(5):1498-503.
14. Kemmler W, von Stengel S. Exercise frequency, health risk factors, and diseases of the elderly. Archives of physical medicine and rehabilitation. 2013;94(11):2046-53.
15. Lustosa LP, Silva JP, Coelho FM, Pereira DS, Parentoni AN, Pereira LS. Impact of resistance exercise program on functional capacity and muscular strength of knee extensor in pre-frail community-dwelling older women: a randomized crossover trial. Revista brasileira de fisioterapia (Sao Carlos (Sao Paulo, Brazil)). 2011;15(4):318-24.
16. Oh SL, Kim HJ, Woo S, Cho BL, Song M, Park YH, et al. Effects of an integrated health education and elastic band resistance training program on physical function and muscle strength in community-dwelling elderly women: Healthy Aging and Happy Aging II study. Geriatrics & gerontology international. 2017;17(5):825-33.
17. Santos GOR, Wolf R, Silva MM, Rodacki ALF, Pereira G. Does exercise intensity increment in exergame promote changes in strength, functional capacity and perceptual parameters in pre-frail older women? A randomized controlled trial. Experimental gerontology. 2019;116:25-30.

18. Serra-Prat M, Sist X, Domenich R, Jurado L, Saiz A, Roces A, et al. Effectiveness of an intervention to prevent frailty in pre-frail community-dwelling older people consulting in primary care: a randomised controlled trial. Age and ageing. 2017;46(3):401-7.
19. Wolf SL, Barnhart HX, Kutner NG, McNeely E, Coogler C, Xu T. Selected as the best paper in the 1990s: Reducing frailty and falls in older persons: an investigation of tai chi and computerized balance training. Journal of the American Geriatrics Society. 2003;51(12):1794-803.
20. Yu R, Wong M, Leung J, Lee J, Auyeung TW, Woo J. Incidence, reversibility, risk factors and the protective effect of high body mass index against sarcopenia in community-dwelling older Chinese adults. Geriatrics & gerontology international. 2014;14 Suppl 1:15-28.
21. Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M. Reliability of the PEDro scale for rating quality of randomized controlled trials. Physical therapy. 2003;83(8):713-21.
22. Lamb SE, Becker C, Gillespie LD, Smith JL, Finnegan S, Potter R, et al. Reporting of complex interventions in clinical trials: development of a taxonomy to classify and describe fall-prevention interventions. Trials. 2011;12:125.
23. Guyatt GH, Oxman AD, Kunz R, Brozek J, Alonso-Coello P, Rind D, et al. GRADE guidelines 6. Rating the quality of evidence--imprecision. J Clin Epidemiol. 2011;64(12):1283-93.