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SYSTEMATIC REVIEW

Is power training or conventional resistance training better for function in elderly persons? A meta-analysis

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Abstract

Objective: to determine the effects of power training with high movement velocity compared with conventional resistance training with low movement velocity for older community-dwelling people.
Design: systematic review of randomised controlled trials.
Data sources: the Cochrane Central Register of Controlled Trials, PubMed (Medline), EMBASE, CINAHL, PEDro and Scholar-Google.
Trials: all randomised or quasi-randomised trials investigating power training with high movement velocity versus conventional resistance training with low movement velocity in elderly persons over the age of 60 years. The primary outcomes were measures of functional outcomes; secondary outcomes were balance, gait, strength, power, muscle volume and adverse effects.
Results: eleven trials were identified involving 377 subjects. The pooled effect size for the follow-up values of the functional outcomes was 0.32 in favour of the power training (95% CI 0.06 to 0.57) and 0.38 (95% CI −0.51 to 1.28) for the change value. The pooled effect from three studies for self-reported function was 0.16 in favour of power training (95% CI −0.17 to 0.49).
Conclusion: power training is feasible for elderly persons and has a small advantage over strength training for functional outcomes. No firm conclusion can be made for safety.

Keywords: *older people, systematic review, resistance training, power training, functional limitations, elderly*

Introduction

To remain independent in daily tasks is an important goal of older persons.

Important determinants of independent mobility are muscle strength and power (i.e. the product of force and movement velocity). In ageing, muscle power declines earlier [1] and faster than strength [2]. Power has a stronger relationship with functional status than muscle strength [3–8].

Besides the effect of age on muscle power, there are some pathological changes in the nervous system that lead to reduced power, for example, impaired voluntary neuromuscular activation [9]. Even very old (>80 years) individuals can still perform explosive-type heavy-resistance exercise (75–80% of the one repetition maximum (1 RM)) and improve power [10].

Power can best be improved by exercising with a resistance that is about 60% of the 1 RM and with the maximum speed at the given resistance (i.e. 'as fast as possible'), which will be about 33–60% of the maximum movement velocity without resistance [11].

There exist reviews on the topic of power training in older persons [12–15], however, there is only one meta-analysis with four trials [16]. Therefore, we wanted to compare the effects of power training (high velocity) with

conventional training (low velocity) on functional outcomes in older persons.

Methods

Search strategy and selection criteria

PubMed (Medline), EMBASE, CINAHL, PEDro, the Cochrane Central Register of Controlled Trials and Google Scholar were searched for all available years until April 2010 without language restriction. The search string for PubMed is available as Supplementary data at *Age and Ageing* online. We adapted this search for the other databases. In addition, we used the PubMed-related articles section and 'cited by' function in Google Scholar and did a hand search of the reference list of relevant articles.

Randomised trials or trials with allocation by minimisation that evaluated the effect of power training versus conventional strength training in older persons were included. We defined power training as a training with moderate resistance and an 'as fast as possible' movement speed for at least the concentric phase of an exercise. We defined conventional strength training as exercises with high or moderate resistance and a slow concentric movement phase. We included studies when an average age of included persons was at least 60 years. Studies with mainly neurological or cardiopulmonary diseases were excluded.

The primary outcomes of interest were measured functional outcomes (e.g. sit to stand, box stepping), secondary outcomes were self-reported function, and measured balance, walking, strength, power and muscle volume or muscle mass, as well as reported adverse effects.

In two steps, irrelevant titles and then abstracts were eliminated by two independent reviewers. Full texts were retrieved and read independently by two reviewers for definite inclusion or exclusion. We resolved disagreement by consensus.

Data extraction

If studies reported data for more than one follow-up timepoint, we decided *a priori* to use only the final follow-up (final values). Sample size of the groups and for continuous outcomes of interest the mean and standard deviation of each group were extracted. If these final values were not available, we extracted values for the change between baseline and the last follow-up. Groups with no intervention or interventions other than conventional strength or power training were excluded. Data were extracted by one of the reviewers and checked by another reviewer. Authors were contacted to obtain missing data. If data were only presented graphically, values were estimated from figures.

Assessment of risk of bias in included studies

Two reviewers independently assessed generation of allocation sequence and concealment of allocation, blinding of assessors and adequacy of analyses. We resolved disagreement by consensus.

Data analysis

We summarised the continuous outcomes with standardised mean differences (SMD, difference of final mean values across treatment groups divided by the pooled standard deviation; or for the change values the difference in change values across treatment groups divided by the pooled standard deviation). We applied the hedges' g correction factor [17]. A SMD of 0.2 indicates an effect of the amount of 0.2 standard deviations, this can be considered a small difference, a SMD of 0.5 indicates a moderate and 0.8 a large difference.

SMDs were pooled with a random effects model. In addition to the 95% confidence interval; a 95% predictive interval was calculated. The predictive interval can be interpreted as the interval in which 95% of the effects of future studies will be. We used standard inverse-variance random-effects meta-analysis to combine trials. Heterogeneity was quantified with the I^2 statistic (percentage of variation across trials that is attributable to heterogeneity rather than to change). An I^2 value of 25% may be interpreted as low, 50% as moderate and 75% as high between-trial heterogeneity. Because final values should not be pooled with change values when SMDs were calculated, we presented the final values and the change values separately. If in a report both values were reported, we used the final values, because fewer articles reported change values.

If more than one outcome-measure was reported for one outcome (i.e. for measured function, reported function, balance etc.), we decided, without the knowledge of the results, which outcome-measure to include. Decisions were based on our judgement of the relative importance of the outcomes. For example, we decided to include sit-to-stand rather than stair climbing for the functional outcomes because sit-to-stand was considered as more basic than stair climbing. Calculations were made using STATA v11 and the user-written command metan.

Results

With the search in the electronic databases and the other search strategies, 641 titles were identified from which 43 were retrieved as full-text and 16 articles on 11 studies with 377 patients fulfilled our inclusion criteria for meta-analyses. Figure 1 provides an overview and reasons for exclusion. Most of the excluded studies did not compare power training versus conventional strength training (i.e. mixed interventions, no clear power training, power versus no training, or one kind of power training versus other kind of power training (e.g. two or three different resistance levels)). Most of the participants in the included studies were older persons with minor functional limitations. See Table S1,

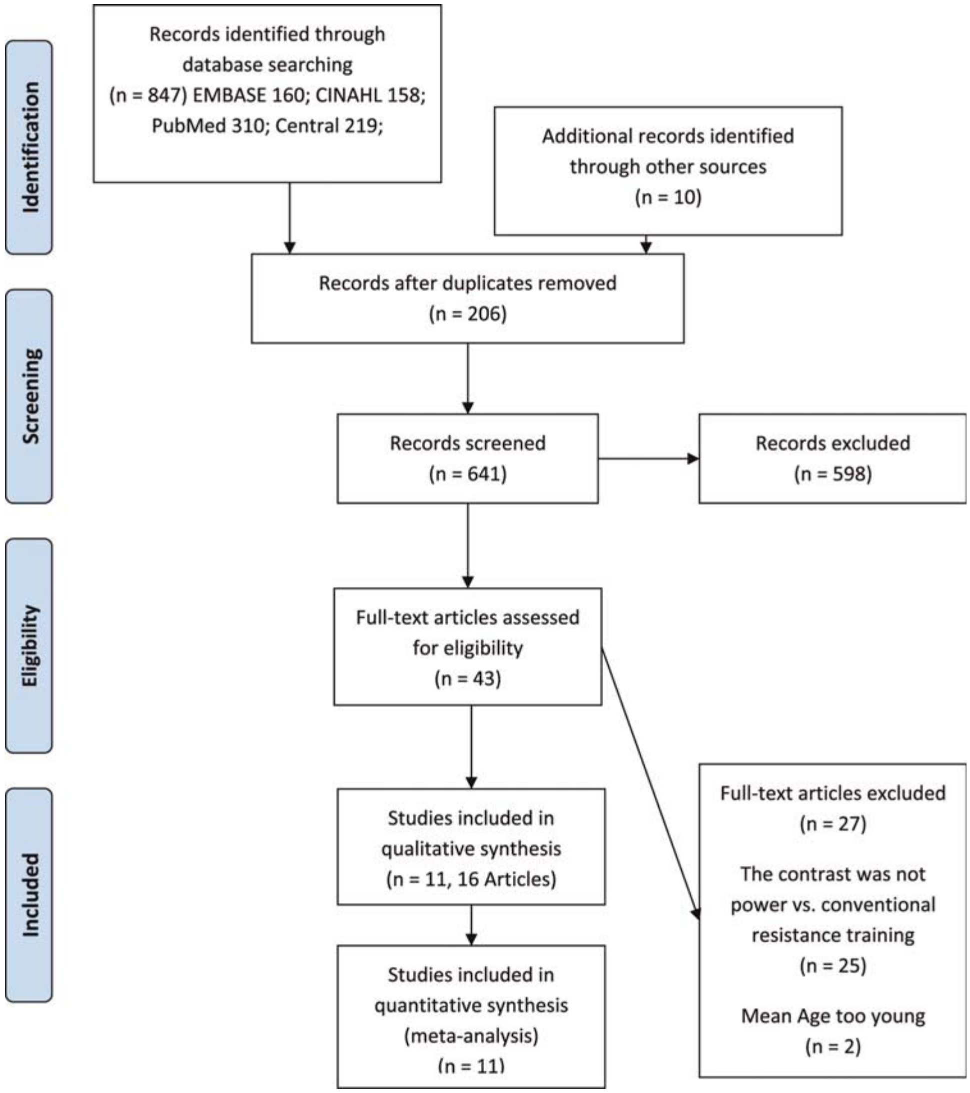

Figure 1. Prisma trial flow diagram [38].

Supplementary data available in *Age and Aging* online, for study characteristics.

Risk of bias/methodological quality

Only two studies mentioned allocation concealment [20, 27] and intention to treat analyses [20, 29]. Blinding of patients and supervisors was not possible. Only three studies reported that the outcome assessors were blinded [20–22]. Two studies had substantial loss to follow-up [23, 24], indicating high risk of bias. Overall, there might be moderate risk of bias.

Intervention characteristics

Most studies used training sessions with 2–3 sets of 8–12 repetitions, thrice per week over a period from 8 to 16 weeks, with a maximum of 24 weeks (see Table S1, Supplementary data available in *Age and Aging* online). All studies had follow-ups immediately after completion of the training period, i.e. there were no follow-ups after a training-free period. The contrast between power and conventional resistance training consisted in the movement velocity, except in one study where both groups moved as fast as possible but with a different load [25]; only four studies had a clear contrast in the exercise load [24–27].

For the power training, two studies used weighted vests and exercises based on functional tasks [20, 21], six studies, reported in 10 articles, used resistance training machines [18, 19, 23, 25, 26, 28–32], one study used mechanically braked cycle ergometer [24], in one study the power group exercised with an inertial load using a flywheel [27] and isokinetic training on a dynamometer was used in one study (two publications) [22, 33]. Training intensities in the power groups were: 40–60% of 1 RM [24, 28, 31], 70% of 1 RM [18, 19, 23, 30, 32], 45–75% of 1 RM [26, 29] and 40% of 2 RM [25].

For the conventional low velocity strength training, one study used chair-based exercises [20], one used free weights [21], seven used exercises on resistance training machines

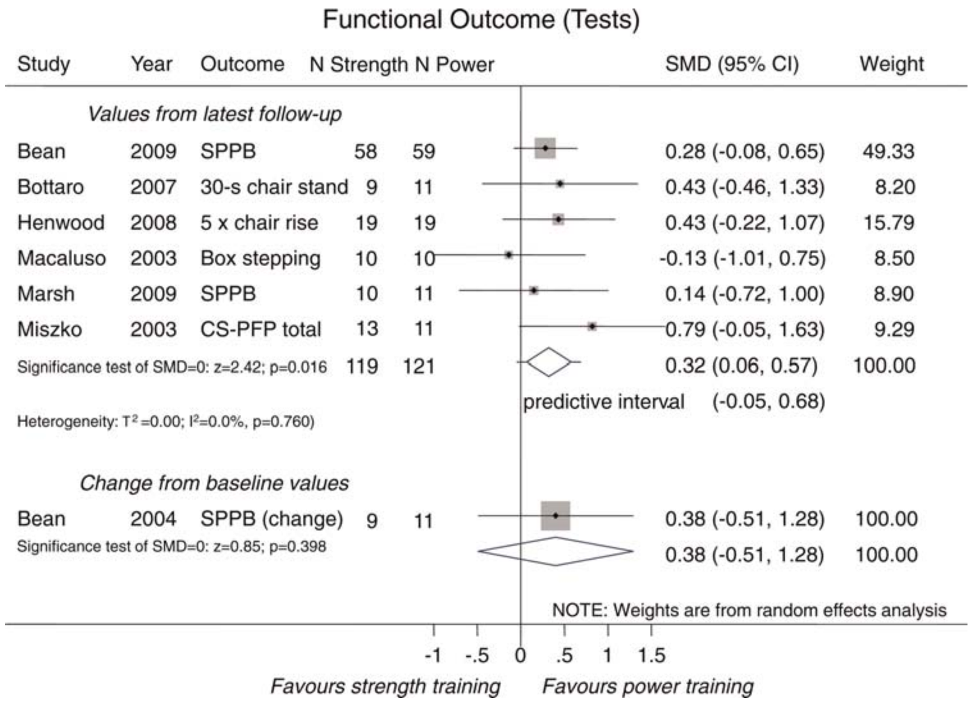

Figure 2. Forrest plot of six trials with values from the follow-up and one study with change values. Values on *x*-axis denote standardised mean difference (SMDs). The plot is stratified according to follow-up values or change scores. Random effects model with predictive interval. The predictive interval indicates the range within which we expect the effects of 95% of future studies will be.

(in 11 publications) [18, 19, 23, 26–32, 34], one used mechanically braked cycle ergometer [24] and one isokinetic training on a dynamometer [22, 33]. The exercise load was: 40–60% of 1 RM [28, 31], 70% of 1 RM [18, 19, 23, 30, 32], 75% of 1 RM [26, 29], 80% of 1 RM [24, 27] and 80% of 2 RM [25].

Functional outcomes

Seven included studies evaluated the differential effect of power training versus conventional strength training on functional outcomes, as for example chair rise tests, box stepping, short physical performance battery (SPPB) or continuous scale physical functional performance (CS-PFP) scores; six studies reported mean and standard deviations at the final follow-up (after 10 weeks of training [28], 12 weeks [28] 16 weeks [21, 24, 25] and 24 weeks) [26], one study only reported change from baseline (12 weeks of training) [20]. The SMD of the pooled data for functional outcomes at follow-up was 0.32 (95% CI 0.06–0.57, $P = 0.016$, level of heterogeneity $I^2 = 0\%$) in favour of power training (Figure 2). This comparison consisted of 121 participants with power training and 119 participants with conventional resistance training. For the change from baseline, the SMD was 0.38 (95% CI −0.51 to 1.28, $P = 0.398$) (11 participants in the power group, 9 in the conventional strength group). There is evidence for a small to medium effect on functional outcome in favour of the power training compared with conventional resistance training. However, the width of the confidence interval indicates that the data are still compatible with a small, clinically non-relevant effect of power training. For one included study with a non-significant effect, no data for the meta-analysis could be extracted [19] (see Table S1, Supplementary data available in *Age and Aging* online; Figure 3).

Self-reported function

We identified two studies (reported in three articles) with self-reported functional outcomes after 12 [23, 30] and 16 weeks of training [21]. The pooled SMD was 0.16 in favour of the power training (95% CI −0.17 to 0.49, $P = 0.351$, $I^2 = 0.0\%$). There is little evidence for a small effect of power training on self-reported functional outcome compared with conventional strength training and it cannot be excluded that the effect of power training is clinically non-relevant or that the strength training is better.

Balance

There were three studies that reported follow-up values for balance [24, 26, 27] and one study with change from baseline [20] (see Table S1, Supplementary data available in *Age and Aging* online, for length of training period). The pooled SMD for the follow-up values was 0.91 in favour of the power training (95% CI −0.17 to 1.99,

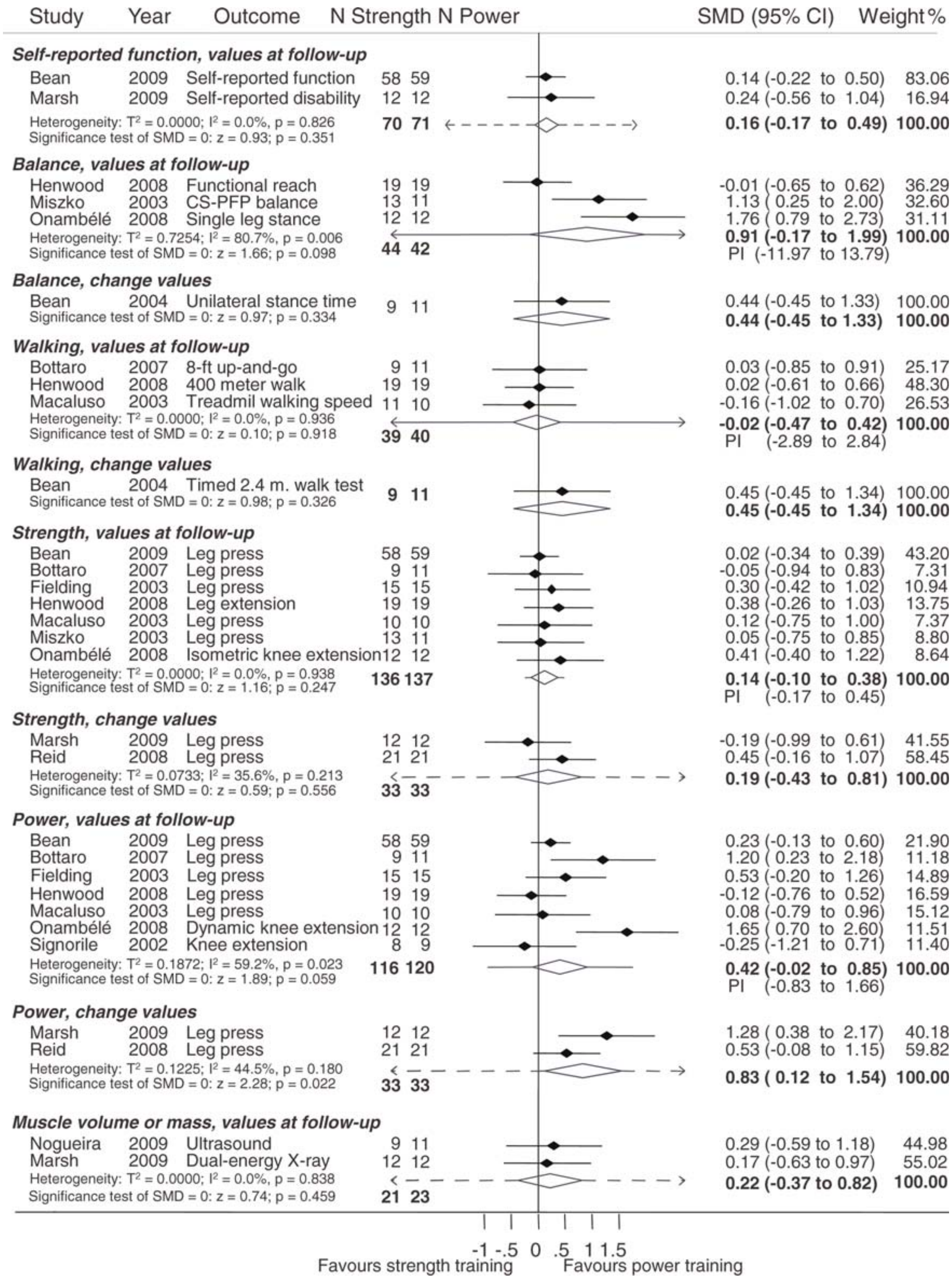

Figure 3. Forest plot stratified according to different outcomes. Values on *x*-axis denote standardised mean difference (SMDs). Random effects model with predictive interval. The predictive interval indicates the range within which we expect the effects of 95% of future studies will be. Dashed line indicates that predictive interval is inestimable and therefore infinitely wide.

$P = 0.098$, $I^2 = 80.7\%$) and the only study with change from baseline had an SMD of 0.44 (95% CI −0.45 to 1.33, $P = 0.334$). There is little evidence for a moderate to large effect of power training on balance compared with conventional strength training, however, it cannot be excluded that the effect of power training is clinically non-relevant or that there is even an advantage for the strength training.

Walking

Values for walking were reported in three studies with follow-up [25, 26, 28] and one study with change values [20]. The pooled SMD for the values from follow-up was −0.02 in favour of the conventional strength training (95% CI −0.47 to 0.42, $P = 0.918$, $I^2 = 0.0\%$). The one study with change from baseline values showed a SMD of 0.45 in favour of the power training for the change value (95% CI −0.45 to 1.34, $P = 0.326$). There is conflicting evidence for the effect of power training on walking-related outcomes.

Strength

We found seven studies with values from follow-up for strength [18, 21, 24, 26–28, 34] and two studies with change values [30, 32]. The pooled SMD was 0.14 (95% CI −0.10 to 0.38, $P = 0.247$, $I^2 = 0.0\%$) for the follow-up values and 0.19 (95% CI −0.43 to 0.81, $P = 0.556$, $I^2 = 35.6\%$) for the change values, both in favour of the power training.

Power

Seven studies were included with follow-up values for power as an outcome [18, 21, 22, 26–28, 34] and two studies with change values [30, 32]. The pooled SMD for the follow-up values was 0.42 in favour of power training (95% CI −0.02 to 0.85, $P = 0.059$, $I^2 = 59.2\%$) and 0.83 (95% CI 0.12–1.54, $P = 0.022$, $I^2 = 44.5\%$) for change values. The widths of the confidence intervals indicate that the data are still compatible with a clinically non-relevant effect or even with an advantage for the strength training.

Muscle volume and muscle mass

Follow-up values for muscle mass or volume were presented in two studies [30, 31]. The pooled SMD was 0.22 in favour of power training with the confidence interval not excluding a better effect for strength training (95% CI −0.37 to 0.82, $P = 0.459$, $I^2 = 0.0\%$).

Adverse effects

One study reported severe adverse events not related to the interventions (cancer and aortic aneurysm in the power group; surgery, pre-existing brain tumour, hiatal hernia and severe fall before start of intervention) [30]. Seven falls were reported in the strength groups [21, 24, 30], and one in a power group [21]. One study reported that two participants in each group stopped because of an exacerbation of osteoarthritis and one subject in the power group because of a recurrence of chronic plantar fasciitis [18]. There were 19 reports in the power group and 20 in the strength group of either minor musculoskeletal discomfort [21], each group had one with chest pain [32], and three patients in the power group and four in the strength group with joint pain [30]. The other studies reported no adverse events.

Discussion

This systematic review on 11 studies with 377 patients and moderate risk of bias showed (i) a small to medium effect on functional outcomes in favour of the power training (high velocity) compared with strength training (low velocity). However, the wide confidence interval ranging from 0.06 to 0.5 indicates that the data are still compatible with a clinically non-relevant difference; (ii) weak evidence (i.e. mostly small studies leading to wide confidence intervals that do not allow us to exclude non-relevant effects or even better outcomes for the conventional strength training) for small to large effects in the outcomes self-reported function, balance, walking, strength, power and muscle mass or muscle volume.

The wide predictive intervals from the random effects models indicate that we cannot exclude that in future studies there will be no differences between the effects of power training or strength training, or that strength training will even show better outcomes.

The power training with moderate resistance and ‘as fast as possible’ movement velocity seems to be a feasible method for older persons who are still relatively fit; however, because of the low number of participants, we were unable to draw a strong conclusion about the safety of the power training. Some studies had an adaptation training period, where participants trained with lower resistance and lower movement speed to allow an adaption of passive and active tissues.

Participants in the included studies were non-frail older persons. Therefore, these results for the power training may not be transferred to frail persons. Furthermore, the nature of the power training requires a certain fitness of the participants and power training is probably not applicable to frail persons.

The strength of our review is the focus on the contrast of power versus conventional strength training and the statistical pooling of the data. One might argue that the outcomes and the interventions were too different to allow statistical pooling. However, our data showed low heterogeneity.

There are several limitations of our review: We did only a comprehensive search on literature published in peer-reviewed journals, and not for results that were either unpublished or only presented at conferences. Therefore, we cannot exclude that there might be substantial publication bias.

There were several limitations in the included studies: For functional outcome, there were only few and mostly small studies, therefore the conclusion for our main outcome might change with the addition of larger studies. Methodological characteristics that might bias the results, for example, blinding of the outcome assessor, intention to treat-analysis or allocation concealment were not consistently reported in the included publications. There is evidence that lack of allocation concealment, lack of blinding and lack of intention to treat analysis may exaggerate the

effect sizes. As blinding of patients and supervisors was not possible, outcome assessors were only blinded in three studies and allocation concealment and intention to treat was only reported in two studies, we cannot exclude the possibility that the results are biased towards a positive effect of the power training.

There might be a problem with baseline differences in the outcome measures between the intervention groups in some studies; this problem is less important if change from baseline values is reported. The positive effect of the power group may partly be due to baseline differences in [**18, 21, 24, 26**]. In contrast, positive effects of the power training might be attenuated, or positive results for the conventional strength training may be partly due to the baseline differences in [**22, 27, 28, 30, 31**]. There is no straightforward solution to this problem as not in all studies analyses were adjusted for baseline differences. However, in the long run, that is, over many randomised controlled studies, baseline differences will be cancelled out.

Our selection of the functional outcomes might have influenced the results, that is, the results could have been different if we had chosen other functional outcomes. However, the selection was made before we knew the results in the studies and therefore, there is no risk for selective reporting bias.

Most studies in this review used an exercise load of about 70% of the 1 RM in the power training group. With the data obtained from this review, we cannot answer the question about optimal exercise load. There is one study (which we excluded because all groups had high movement velocity) that compared different exercise loads with high velocity [**35–37**]. There were differential effects on different outcomes, for example, balance improved most with low exercise load [**35**].

One advantage of power training might be that it is perceived as less exhaustive than conventional strength training [**13**].

Power training with high movement velocity and moderate exercise load (about 50–60% of 1 RM) should be compared in a larger study to low movement velocity training with high exercise load (about 70–80% of 1 RM) for functional outcomes.

Key points

- Power training was compared with conventional strength training in 11 randomised or quasi-randomised trials.
- Improvements in functional outcomes were slightly larger with power training.
- No firm conclusion can be made for safety.

Conflicts of interest

None declared.

Supplementary data

Supplementary data mentioned in the text is available to subscribers in *Age and Ageing* online.

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The very long list of references supporting this review has meant that only the most important are listed here and are represented by bold type throughout the text. The full list of references is available at *Age and Ageing* online.

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