Controlled endurance exercise training and VO2max changes in older adults: a meta-analysis
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CRD summary
This review concluded that endurance training improves aerobic capacity in older sedentary adults, thus protecting against cardiovascular aging and improving quality of life. There were limitations to the review but, overall, the authors' conclusion about the positive effect on aerobic capacity is likely to be reliable. There was no evidence for the other outcomes.

Authors' objectives
To evaluate the effects of aerobic exercise on maximal oxygen consumption (VO2 max) in sedentary older adults. The review also examined the influence of study, patient and intervention characteristics on this outcome.

Searching
MEDLINE (via PubMed), SPORTDiscus, HealthSTAR, Current Contents (Chemical Medicine) and Dissertations Online were searched using a broad search strategy (no details of the keywords were reported). Professional books and journals, position statements of national or international organisations, and reference lists of published reviews and selected studies were handsearched. Experts in the field were contacted for details of additional studies. Abstracts from publications, conference proceedings and dissertations were screened, but these were not included. Studies were only eligible if they had been published in English and/or indexed as journal articles after 1980.

Study selection
Study designs of evaluations included in the review
Randomised controlled trials (RCTs) and non-randomised controlled trials (non-RCTs) were eligible for inclusion.

Specific interventions included in the review
Studies that compared training programmes of aerobic exercise and/or conditioning lasting at least 2 weeks with a nonintervention control were eligible for inclusion. The studies had to use no other exercise interventions or treatments; studies that used concomitant weight loss interventions were excluded.

Most of the included studies providing relevant information used a no treatment control; others used waiting-list, attention, placebo and participants in other studies at the same location. The majority of the studies were conducted in the USA, mainly in universities and colleges. Most studies used walking as the main form of exercise; other studies used elements of walking, jogging, cycling, stair climbing, aerobic dance, tai chi chuan, outdoor performance and aerobic games. Exercise sessions were mainly conducted three times a week (range: 1 to 4.9) and the mean duration was 38.1 minutes per session (range: 20 to 60). Exercise intensity varied amongst the studies; where reported, the mean intensity measured using the percentage of maximal heart rate ranged from 60 to 85%, VO2 max ranged from 50 to 82% in 10 groups, heart rate reserve ranged from 35 to 80%, and the maximal heart rate ranged from 107 to 129 beats per minute.

Participants included in the review
Studies of apparently healthy older participants with a mean age of 60 years or older were eligible for inclusion. Approximately half of the participants in the included studies were female; 34.1% of studies included only females and 9.8% only males. Most of the studies reporting the relevant information reported the inclusion of healthy participants; 2 studies included patients with hypertension. The baseline VO2 max ranged from 14.7 to 31.5 mL/kg per minute across treatment groups.

Outcomes assessed in the review
Studies that reported changes in VO2 max were eligible for inclusion.
How were decisions on the relevance of primary studies made?
The authors did not state how the papers were selected for the review, or how many reviewers performed the selection.

Assessment of study quality
The studies were assessed and scored using the 3-item Jadad scale. The authors did not state how the validity assessment was performed.

Data extraction
The data were coded and extracted using a data abstraction form. A random sample of studies was subjected to reliability checks conducted approximately 10 days apart. This resulted in the re-coding of 12 studies. Discrepancies were resolved through reviewing, checking and discussion. For each study, reported means and standard deviations (SDs) were extracted for the outcome of interest and used to calculate standardised effect sizes (ESs) with 95% confidence intervals (CIs). For studies with more than one intervention group, the mean outcome measure was extracted for each treatment and treated as separate treatments.

Methods of synthesis
How were the studies combined?
Pooled ESs and 95% CIs were calculated for exercise versus control using a random-effects model where significant heterogeneity was found; both fixed-effect and random-effect models were used in the absence of significant heterogeneity. The pooled means and SDs of the participants' physical characteristics were calculated for the exercise and control groups. Pooled ESs with 95% CIs were also calculated for the change in VO2 max from baseline for the exercise and control interventions separately. A funnel plot was used to assess publication bias.

How were differences between studies investigated?
Statistical heterogeneity was assessed using the Q statistic. A subgroup analysis was used to examine the effects of study design (randomisation, study year, sample size and country), physical characteristics of the participants (age, gender, baseline blood-pressure, body mass index) and characteristics of intervention (duration of exercise, frequency and intensity). There were insufficient data to examine the effects of ethnicity, health status and medication.

Results of the review
Forty-one controlled clinical trials were included (n=2,102 analysed): 23 RCTs and 18 non-RCTs.

The quality scores ranged from 0 to 4 out of 5. Seven studies reported the use of matching procedures. One study reported the use of intention-to-treat analysis; other studies used a per-protocol analysis. The drop-out rates ranged from 0 to 69%.

The funnel plot showed no evidence of publication bias.

The meta-analysis showed that aerobic exercise significantly increased VO2 max compared with control; the ES was moderate (0.64, 95% CI: 0.56, 0.73, p<0.001). No significant heterogeneity was found (Q=66.03%, p>0.05). The net change in VO2 max was 3.78 mL/kg per minute (95% CI: 3.24, 4.33, p<0.001).

The subgroup analysis showed greater improvements in VO2 max with exercise programmes lasting more than 20 weeks and with exercise intensity of approximately 60 to 65% but less than 70%. The results of these subgroup analyses were not reported. Treatment effects were greater for non-RCTs than RCTs, but the difference was not statistically significant; the mean difference was 0.91 (95% CI: -1.87, 0.061, p=0.066). Using only data from RCTs, aerobic exercise significantly increased the ES (0.68, SD 0.42) and VO2 max (3.40 mL/kg per minute, SD 1.59) compared with controls (95% CIs were not reported).

Authors' conclusions
Endurance training improves aerobic capacity in older sedentary adults and therefore protects against cardiovascular aging and improves quality of life.

**CRD commentary**
The review addressed a clear question that was defined in terms of the participants, intervention, outcomes and study design. Several relevant sources were searched, but no attempts were made to minimise language or publication bias; appropriate methods were used to examine the potential for publication bias and no evidence of this was found. Methods were used to minimise reviewer errors and bias in the extraction of data, but it was unclear whether similar steps were taken at the study selection and validity assessment stages. Study quality was assessed using an instrument designed for RCTs and not non-randomised studies. The aggregated validity score was reported but only some of the individual validity items were given; the level of blinding was not reported.

The characteristics of the participants and interventions were adequately summarised. Statistical heterogeneity was assessed for the main meta-analysis, but the pooling of data from randomised and non-randomised studies might not have been appropriate. However, the author did use a subgroup analysis to examine the influence of randomisation and other factors on the results; statistical heterogeneity was not reported for these subgroup analyses. There were limitations in the reporting of the review methods but, overall, the authors’ conclusion regarding the effects on aerobic capacity is likely to be reliable. However, there was no evidence presented about the direct effects of exercise on cardiovascular aging and quality of life, and these conclusions should be viewed with caution.

**Implications of the review for practice and research**
The authors did not state any implications for practice or further research.

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**Other publications of related interest**

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**Record Status**
This is a critical abstract of a systematic review that meets the criteria for inclusion on DARE. Each critical abstract
contains a brief summary of the review methods, results and conclusions followed by a detailed critical assessment on the reliability of the review and the conclusions drawn.