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[Intervention Review]

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ABSTRACT

Background

Physical activity is beneficial for healthy ageing. It may also help maintain good cognitive function in older age. Aerobic activity improves cardiovascular fitness, but it is not known whether this sort of fitness is necessary for improved cognitive function. Studies in which activity, fitness and cognition are reported in the same individuals could help to resolve this question.

Objectives

To assess the effectiveness of physical activity, aimed at improving cardiorespiratory fitness, on cognitive function in older people without known cognitive impairment.

Search methods

We searched MEDLINE, EMBASE, PEDro, SPORTDiscus, PsycINFO, CINAHL, Cochrane Controlled Trials Register (CENTRAL), Dissertation abstracts international and ongoing trials registers on 15 December 2005 with no language restrictions.

Selection criteria

All published randomised controlled trials comparing aerobic physical activity programmes with any other intervention or no intervention with participants older than 55 years of age were eligible for inclusion.

Data collection and analysis

Eleven RCTs fulfilling the inclusion criteria are included in this review. Two reviewers independently extracted the data from these included studies.

Main results

Eight out of 11 studies reported that aerobic exercise interventions resulted in increased cardiorespiratory fitness of the intervention group (an improvement on the maximum oxygen uptake test which is considered to be the single best indicator of the cardiorespiratory system) of approximately 14% and this improvement coincided with improvements in cognitive capacity. The largest effects on cognitive function were found on motor function and auditory attention (effect sizes of 1.17 and 0.50 respectively). Moderate effects were observed for cognitive speed (speed at which information is processed; effect size 0.26) and visual attention (effect size 0.26).

Authors' conclusions

There is evidence that aerobic physical activities which improve cardiorespiratory fitness are beneficial for cognitive function in healthy older adults, with effects observed for motor function, cognitive speed, auditory and visual attention. However, the majority of comparisons yielded no significant results.

The data are insufficient to show that the improvements in cognitive function which can be attributed to physical exercise are due to improvements in cardiovascular fitness, although the temporal association suggests that this might be the case. Larger studies are still required to confirm whether the aerobic training component is necessary, or whether the same can be achieved with any type of physical exercise. At the same time, it would be informative to understand why some cognitive functions seem to improve with (aerobic) physical exercise while other functions seem to be insensitive to physical exercise.

Clinicians and scientists in the field of neuropsychology should seek mutual agreement on a smaller battery of cognitive tests to use, in order to render research on cognition clinically relevant and transparent and heighten the reproducibility of results for future research.

PLAIN LANGUAGE SUMMARY

Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Physical activity is beneficial for healthy ageing. It may also help maintain good cognitive function in older age. Aerobic activity improves cardiovascular fitness, but it is not known whether this sort of fitness is necessary for improved cognitive function.

Eleven studies of aerobic physical activity programmes for healthy people over the age of 55 years have been included in this review. Eight of these 11 studies reported that aerobic exercise interventions resulted in increased fitness of the trained group and an improvement in at least one aspect of cognitive function. The largest effects were on cognitive speed, auditory and visual attention. However, the cognitive functions which improved were not the same in each study and the majority of comparisons yielded no significant results.

The data are insufficient to show that the improvements in cognitive function which can be attributed to physical exercise are due to improvements in cardiovascular fitness.

BACKGROUND

Description of the condition

In 2005 over 925 million people worldwide were 55 years of age or older according to the population database of the United Nations (WPP 2006). It is predicted that in 10 years this age group will grow to over 1.4 bilion. Subjective complaints about cognitive capacities increase with (older) age (Martin 2003; Newson 2006) and an objective decline in cognitive performance accelerates around the age of 50 (Salthouse 2003; Verhaeghen 1997), with the exception of cognitive skills with a large knowledge component. Research has shown that a regular exercise programme can slow down or prevent functional decline associated with ageing and improve health in this age group. The benefits for older people who regularly participate in endurance, balance and resistance training programmes are well established. Such health benefits include improved muscle mass, arterial compliance, energy metabolism, cardiovascular fitness, muscle strength, overall functional capacity (Lemura 2000), and the maintenance or even enhancement of cognitive function (Colcombe 2003).

Description of the intervention

Research using animal models has provided insight into the possible cellular and molecular mechanisms that underlie the effects of physical activity on cognitive function. Increased aerobic fitness is found to increase cerebral blood flow, oxygen extraction and glucose utilisation (Churchill 2002) as well as an activation of growth factors which mediate structural changes such as capillary density (Cotman 2002). A preliminary survey of the literature on human research points towards the same possible physiological mechanisms that could explain the association between physical activity and cognitive vitality (Aleman 2000; McAuley 2004; Prins 2002;

Rogers 1990). The assumption is made that improvements in cardiovascular (aerobic) fitness mediate the benefits in cognitive capacity (McAuley 2004; Kramer 1999). This cardiovascular fitness hypothesis therefore implies that changes in cognitive function are preceded by changes in aerobic fitness.

How the intervention might work

Evidence for the link between physical activity, cardiovascular fitness and cognitive function in older individuals is provided by several longitudinal studies (Abbott 2004; Barnes 2003; Laurin 2001; Richards 2003; Sturman 2005; van Gelder 2004) and randomised controlled trials (Bakken 2001; Binder 1999; Emery 1998; Fabre 2002). Results from training studies performed by Hill et al. (Hill 1993) and Blumenthal et al. (Blumenthal 1991), however, failed to correlate changes in aerobic power (VO_2 max) with changes in cognitive measures. At the same time, studies seldom report combinations of activity, fitness and cognition in a single study. Several randomised controlled studies, as described in the meta-analysis reported in Colcombe and Kramer (Colcombe 2003), concluded that aerobic fitness training enhances the cognitive capacity of healthy older adults. The meta-analysis of Etnier et al. (Etnier 1997 b) showed similar results but also included several non-randomised clinical trials. The meta-analysis of Heyn et al. (Heyn 2004) found a similar effect of physical activity on cognitive function in people with dementia and cognitively impaired older adults.

Why it is important to do this review

Although these meta-analyses report a robust effect of physical activity on cognitive function, it remains unclear whether improvement in cardiovascular fitness (reflected by cardiovascular parameters such as VO_2 max) accounts for the effects of physical activity on cognitive capacity. Individual physiological or psychological mechanisms other than aerobic fitness might still account for the effects found in these meta-analyses. The present review intends to investigate a hypothesised link between physical activity aimed at the improvement of cardiorespiratory fitness and cognitive function.

OBJECTIVES

To assess the effectiveness of physical activity, aimed at improving cardiorespiratory fitness, on cognitive function in older people without known cognitive impairment.

METHODS

Criteria for considering studies for this review

Types of studies

All randomised clinical trials (published in journals) which met the given inclusion criteria were considered even if the participants were non-blinded. No language restrictions were applied.

Types of participants

Studies in older people and studies examining frail participants with age-related illnesses (such as osteoporosis, arthrosis, etc.) or specific disorders (like Chronic Obstructive Pulmonary Disease (COPD), heart failure, etc.) were included. Participants had to be aged 55 or older and not cognitively impaired in any way (e.g. suffering from dementia in any form, postcerebrovascular accident (CVA), or suffering from depression). Studies including participants just recovering from any surgical treatment were not included in this systematic review, nor those including participants with any co-morbidity that precludes successful participation in exercise programmes.

Types of interventions

Physical activity was considered to be any programme of exercise of any intensity, duration or frequency which was aimed at improving cardiorespiratory fitness. Acceptable comparison interventions were: no programme or treatment; a strength or balance programme; a programme of social activities or mental activities.

Types of outcome measures

The primary outcome measurement was cognitive function, either tested with a neuropsychological test battery (a combination of several tests sensitive to changes in cognitive function in adults) or tested with the Mini Mental Status Examination (MMSE) which gives a global measure of cognitive function. At the same time at least one of the following parameters reflecting cardiorespiratory fitness should have been reported in the article: maximal VO_2, estimated maximal VO_2 or other fitness-related parameters.

Search methods for identification of studies

We searched MEDLINE, EMBASE, PEDro, SPORTDiscus, PsycINFO, CINAHL, Cochrane Controlled Trials Register (CENTRAL), Dissertation Abstracts International and ongoing trials registers on 15 December 2005 with no language restrictions. References in the included studies and in reviews of the literature were screened. Contact was made with experts and associations.
We used a combination of MeSH and text-based terms to find records of physical activity, including: exercise*, motor activit*,

leisure activit*, physical fitness, physical endurance, exercise tolerance, exercise test, aerobic, aerobic capacity, physical activity, physical capacity, physical performance, training.

To reduce our findings to those records that measure cognition and cardiorespiratory fitness, we searched using the terms: cognit*, mental process*, maximal VO_2, estimated maximal VO_2, METS, Watts, treadmill speed, inclination.

To reduce our findings further to those records that deal with the older adult population ,we used relevant MeSH and text-based terms: adult*, middle aged, aged, elderly, old*, geriatric, frail.

Finally, we reduced the results to only RCTs and CCTs using the MEDLINE search strategies for optimal sensitivity in identifying randomised clinical trials (Higgins 2005).

Data collection and analysis

Selection of s tudies

Two reviewers (MA and GA) assessed the titles and available abstracts of all studies identified by the initial search and irrelevant studies were excluded. Two reviewers (MA and GA), using the inclusion criteria described above, independently assessed full paper copies of reports of potentially relevant studies. Disagreements on inclusion were resolved by discussion and through arbitration by a third reviewer (LV).

Quality assessment

Two reviewers (MA and GA) independently evaluated the methodological quality of the selected articles. We used the criteria list for quality assessment of nonpharmaceutical trials (CLEAR NPT) developed using consensus (Boutron 2005). This checklist includes information on sampling method, measurement, intervention and reporting of biases and limitations, as presented in Table 1. A small pilot exercise to clarify the method was performed with some articles that were already excluded from the review process. Cohen's kappa (K) was calculated as a measure of inter-observer agreement, and relied on Landis and Koch's benchmarks for assessing the relative strength of agreement (Landis 1977). Discordance in assessment was resolved after a single round of discussion and arbitration by a third reviewer (LV).

Data e xtraction

Data were extracted from the published reports by two reviewers (MA and GA) working independently and entered into RevMan by the first author, with full agreement of the second author. The summary statistics required for each trial and each outcome for continuous data were the mean change from baseline, the standard error of the mean change and the number of participants for each treatment group at each assessment. In some cases (Hassmén 1997 a; Hassmén 1997 b; Moul 1995; Kramer 2001) the standard error of mean had to be converted in a standard deviation, using SE = SD/sqrtN. For each outcome measure, data was sought on every participant randomised. To allow an intention-to-treat analysis, the data was sought irrespective of compliance, whether or not the participant was subsequently deemed ineligible, or otherwise excluded from treatment or follow-up. If intention-to-treat data were not available in the publications, "on-treatment" data, or the data of those who completed the trial, were sought and indicated as such. For cognitive data in which a higher score denotes worse performance (e.g. reaction times, digit vigilance, trail making part A, trail making part B, Stroop interference data and error rates), the mean change from baseline was entered as a negative variable.

Data a nalysis

Cognitive function was measured with various rating scales in the included articles. The neuropsychological tests found in the included RCTs were categorised (see Table 2) into a number of categories that approximately measures the same construct (Lezak 2004; Kessels 2000). At the same time, some cognitive tests were not admitted since double representation of studies in their cognitive category would have compromised the validity of the outcomes. The Weighted Mean Difference (WMD) was used if studies used the same cognitive tests and if the outcome measurements were on the same scale. In all other cases the Standardised Mean Difference (SMD) was calculated. If just one study reported results on a cognitive function, a fixed effects model was used. In all other cases (multiple studies) the random effects model was used.

The possible effects of aerobic exercise were analysed versus any intervention (strength programme, flexibility or balance programme, social or mental programme) and versus no intervention (controls or waiting list). Fabre et al. (Fabre 2002) subjected a group of participants to mental training and subsequently data from this group of participants was kept out of analyses of memory effects. In order to elucidate potential effects of the various intervention protocols on cognitive outcome measures, analyses were also performed separately (e.g. aerobic exercise versus strength programme).

As an extension to subgroup analyses, a meta-regression would allow the effect of cardiovascular fitness (VO_2 max or any other measure of aerobic fitness expressing "fit" versus "unfit" individuals) to be investigated. Meta-regression however was not considered in the present review since there were fewer than 10 trials in the meta-analysis.

RESULTS

Description of studies

The search strategy rendered 31 promising abstracts. The full text of five theses could not be traced in peer reviewed journals (see list of studies awaiting assessment). Twenty-eight studies were excluded for various reasons after screening of the full text articles (see characteristics of excluded studies). The following 11 studies were all suitable for inclusion.

Bakken et al. (Bakken 2001) published a RCT in which 15 participants aged 72 to 91 years were randomly assigned to an aerobic exercise group (n = 8) or a wait list control group (n = 7) for eight weeks. The aerobic exercise group trained in one hour sessions for three sessions per week. Duration and intensity increased over the weeks but the subjects' heart rates did not exceed the upper limit of their target heart rate reserve. The main cognitive outcome parameter was a "tracking test" (visual attention). Five participants were available for analysis in each group. Rate-pressure product (RPP) was used to determine if an aerobic training effect had taken place. Both groups showed slight increases in RPP from pre-test to post-test.

Blumenthal et al. (Blumenthal 1989 a; Blumenthal 1989 b) performed a RCT in which 101 men and women aged 60 to 83 years were randomly assigned to either an aerobic exercise training (n = 33), a yoga/flexibility programme (n = 34) or a waiting list control group (n = 34). The aerobic exercise programme consisted of three supervised sessions for 16 weeks. The aerobic training was based on 70% of maximum heart rate achieved on the baseline exercise test. The yoga/flexibility group trained two times a week for 16 weeks and the control group was instructed not to change their physical activity habits and especially not to engage in any aerobic exercise for the study period. Two subjects were lost from the aerobic group and two were lost from the waiting list group. Blumenthal et al. included tests for cognitive speed, verbal, visual and working memory as well as executive functions, cognitive inhibition, visual and auditory attention and motor function in this study. A summary combination of the scores on both 2&7 test (letters and digits) was calculated and standard deviations were pooled and used in analysis. Subjects in the aerobic training group experienced a significant 11.6% increase in their VO_2 max (from 19.4 to 21.4 ml/kg/min), whereas the participants in the yoga/flexibility and control groups experienced a 1 to 2% decrease in VO_2 max (from 18.8 to 18.7 ml/kg/min and 18.5 to 17.9 ml/kg/min, respectively). Blumenthal and colleagues described the results for men and women separately in their article. In this review the data presented in Blumenthal 1989 a reflects the data of the women, Blumenthal 1989 b those of the men.

In the RCT of Emery and Gatz (Emery 1990 a) a total of 48 men and women aged 61 to 86 years were randomly assigned to an exercise programme (n = 15), a social activity group (n = 15) or a control group (n = 18). The exercise programme consisted of stretching exercises, aerobic exercise (at 70% of age-adjusted maximum heart rate = 220-age) as well as rhythmic muscle strengthening exercises (e.g. repeatedly standing up and sitting down), three times a week for 12 weeks. Subjects in the social programme participated in non-physical activities (card games, art projects, political discussion groups, watching films) three times a week for 12 weeks. Because attrition from the social group was comparable to that of the control group, and because attendance for the social group was poor overall (ranged from 10 to 94%), the analyses were conducted with the two groups pooled. One subject was lost from analyses in the exercise group, four from the social group and four from the control group. This study included tests for cognitive speed and auditory attention in its design. Resting heart rate, maximum heart rate and systolic/diastolic blood pressure indicated no significant differences between the groups. Both groups showed a significant time main effect decrease in diastolic blood pressure, other measures indicated no significant effects.

Emery et al. (Emery 1998) published a second RCT of 79 COPD patients aged 66.6 ± 6.5 years. Twenty nine participants were randomly assigned to an exercise/education/stress management group (EXESM), 25 subjects to an education/stress management group (ESM) and 25 participants were assigned to a control group. EXESM participants trained during a 10-week period. The training included aerobic exercises as well as strength training on Nautilus equipment, educational lectures on topics relevant for COPD patients and a weekly group meeting for stress management and psychological support. In the first five weeks, EXESM participants followed a programme of daily sessions with 45 min of aerobic exercise, lectures on relevant COPD topics and a stress management meeting. Following the initial five weeks, EXESM participants then participated in five more weeks of exercise for three times a week, 60 to 90 min and one hour a week of stress management. ESM consisted of 16 educational sessions and 10 stress management classes in 10 weeks. Controls were instructed not to alter their physical activities during the study. Four subjects were lost from the EXESM group and two subjects were lost from the ESM group. Tests on cognitive speed, visual attention, executive and motor functions were incorporated in this study. Participants in the EXESM condition achieved a significant 16% gain in VO_2 max (from 12.4 to 14.4 ml/kg/min), whereas participants in the other two groups showed no significant changes in VO_2 max (ESM from 12.0 to 11.7 ml/kg/min and controls from 11.1 to 10.8 ml/kg/min).

The RCT of Fabre et al. (Fabre 2002) presented data from 32 men and women aged 60 to 76 years. Participants were randomly assigned to an aerobic exercise programme (n = 8), a mental training programme (n = 8), a combined aerobic/mental programme (n = 8) or a control group (n = 8); no one was lost to follow-up. Physical training consisted of two supervised exercise sessions per week for two months: walking and running to maintain target heart rate (target heart rate corresponded to the ventilatory threshold). Subjects in the mental training programme met once a week for two months and Israel's method (Israel 1987) was used. The controls met as many times as the other groups for leisure activities such as singing. Fabre and colleagues included tests for verbal and visual memory, perception and executive functions in their study. The physical training resulted in an average significant increase in VO_2 max of 12% (from 1350 to 1630 ml/min) and 11% (from 1510 to 1625 ml/min) in the aerobic training group and the combined aerobic/mental group, respectively. The VO_2 max scores of the participants in the other two groups were unchanged compared to initial values (mental training group from 1060 to 999 ml/min and controls from 1256 to 1265 ml/min).

Hassmén and Koivula (Hassmén 1997 a; Hassmén 1997 b) presented an RCT in which 40 men and women aged 55 to 75 years were randomly assigned to an exercise group (n = 20) or a control group (n = 20), no one was lost to follow-up. Participants in the exercise group walked three times a week during three months with intensities according to "Rating of Percieved Exertion" (RPE, Borg scale) of 9 (very light), 11 (fairly light) and 13 (somewhat hard). The performed exercise gave rise to heart rate responses of 95 to 125 beats/min. Subjects in the control group were given home assignments to be performed three times per week. Cognitive speed, verbal memory, perception and auditory attention were tested in the participants. Heart rate data and data on RPE showed no significant differences between the groups over time. The results for men and women were described separately in this article. In this review the data presented in Hassmén 1997 a reflects the data of the women, Hassmén 1997 b those of the men. A total of 174 participants, aged 60 to 75 years, were included in the RCT of Kramer et al. (Kramer 2001). After randomisation and testing, 124 individuals remained in analyses; 58 (13 men) in the aerobic walking group and 66 (20 men) in the stretching and toning programme. Participants in the aerobic programme walked briskly in three supervised sessions per week for six months. After warming up they spent 40 minutes on brisk walking (gradually beginning at 10 to 15 minutes up to 40 minutes) and finished with a cooling down. Initial exercise was performed at 50 to 55% of VO_2 max and increased to 65 to 70% of VO_2 max. The subjects in the stretching and toning programme met three times a week for six months. The programme emphasized stretches for all the large muscle groups of the upper and lower extremities. Each stretch was held for 20 to 30 seconds and repeated 5 to 10 times. Each session was preceded and followed by 10 minutes of warm-up and cooling down. Cognitive speed, verbal and visual memory, perception, executive and motor functions as well as cognitive inhibition, visual and auditory attention were assessed with various cognitive tests. Mean results of the subtests of the pursuit rotor task, Rey's auditory verbal learning test, spatial attention and visual search task were summed and divided by the number of tasks. Standard deviations of these subtests were pooled. The physical training resulted in improvements of 5.1% on VO_2 max measures (from 21.5 to 22.6 ml/kg/min). The toning group showed a 2.8% decrease in VO_2 max scores (from 21.8 to 21.2 ml/kg/min).
Madden et al (Madden 1989) published an RCT of 85 men and women 60 to 83 years of age. All participants were randomly assigned to either an aerobic exercise group (n = 28), a yoga group (n = 30) or a control group (n = 27). The subjects in the aerobic exercise group trained three times per week for 16 weeks and all exercise was performed in target (training) heart range (70% of maximum during initial exercise test). Subjects in the yoga group participated in supervised sessions twice a week during 16 weeks. The controls were instructed not to change their physical activity habits for the length of the study. A total of six subjects were lost from analyses; three from the aerobic exercise group, two from the yoga group and one from the control condition. All mean error rates for the word comparison task (executive functions) and the letter search task (visual attention) were recalculated into summary scores. Standard deviations of these two tasks were pooled. Aerobic capacity remained constant for the yoga and control groups between pre- and post-test (respectively from 18.8 to 18.6 ml/kg/min and from 19.1 to 18.6 ml/kg/min), whereas the aerobic exercise group showed a significant 11% increase in VO_2 max (from 19.7 to 21.9 ml/kg/min).

Moul et al. (Moul 1995) presented data of an RCT in which 30 men and women aged 65 to 72 years of age were randomly assigned to a walking condition (n = 10), weight training (n = 10) or control condition (n = 10) for 16 weeks. No one was lost to follow-up. Participants in the walking condition walked five times per week for 30 minutes at 60% of "Heart Rate Reserve" (HRR, as determined by treadmill testing). Walking duration was increased two minutes per week until they reached 40 minutes and HRR values were adjusted after eight weeks of training to 65% of HRR. Weight training consisted of five sessions per week of upper and lower body exercises on alternate days of the week. Abdominal crunches and back extension were performed each session. The weight training group employed a "Daily Adjusted Progressive Resistive Exercise Program" (DAPRE) using weights. Subjects in the control condition met five times per week for mild stretching exercises which challenged the cardiovascular or muscular systems minimally. All participants were kept in analyses. The Ross Information Processing Assessment was used to evaluate changes in cognitive function. Post-test data revealed that the subjects in the walking condition significantly increased their VO_2 max by an average of 16% (from 22.4 to 26.6 ml/kg/min), whereas there were no significant changes in VO_2 max for the other two groups (weight training group from 21.4 to 20.4 ml/kg/min and controls from 20.9 to 19.3 ml/kg/min).

The RCT of Panton et al. (Panton 1990) included data on 49 retired university professionals (23 males and 26 females), aged 70 to 79 years. The participants were randomly assigned to a walk/jog group (n =17), a strength group (n = 20) or a control condition (n = 12) for 26 weeks. A total of eight participants were lost to follow-up; it is unclear from which group these subjects were lost. Subjects in the walk/jog condition participated in three exercise sessions per week for the duration of the study. Initially, participants started walking/jogging for 20 minutes at 50% of

their maximal heart rate reserve (HRRmax). The duration was increased by 5 min every two weeks until the subjects walked for 40 minutes. Training intensity was gradually increased until subjects could walk at 60 to 70% of their HRRmax. During the 14th week of training, exercise intensity was further increased by alternating fast walk/moderate walk or fast walk/slow jog intervals. Five participants increased their training intensity by increasing the slope of the treadmill. By the 26th week of training, all subjects performed at 85% of HRRmax for 35 to 45 min. Participants in the strength group had workout sessions for three times a week for 30 min per session. The workouts consisted of one set of 10 variable resistance Nautilus exercises (leg, arm and torso muscles). During the first 13 weeks, subjects used light to moderate weights and performed 8 to 12 repetitions for each exercise. During the last 13 weeks, resistance was increased substantially and subjects were encouraged to train to volitional muscular fatigue. When subjects could complete 12 or more repetitions, the resistance was increased. The controls were asked not to change their lifestyle over the six month duration of the study. Tests for cognitive speed were performed to analyse cognitive function. Aerobic capacity significantly improved by 20.4% (from 22.5 to 27.1 ml/kg/min) for subjects in the walk/jog group; participants in both the strength as well as the control group showed no significant changes in VO_2 max (from 22.5 to 23.3 and 22.2 to 22.0, respectively).
Whitehurst (Whitehurst 1991) published an RCT on 14 females aged 61 to 73 years. The subjects were randomly assigned to an exercise programme (n = 7) or a control condition (n = 7) for eight weeks. No one was lost to follow-up. The exercise condition consisted of three supervised sessions per week. The subjects cycled for 8 to 10 minutes the first week to provide acclimation. Thereafter, 3 to 5 minutes was added to subsequent sessions so that by week 4 all subjects were cycling for 35 to 40 minutes at their target heart rate (70 to 80% of predicted maximum by submaximal bicycle test). The controls were instructed not to engage in any form of vigorous physical activity during the course of the study. Choice reaction times were tested for evaluation of cognitive function. The subjects in the exercise group significantly increased their VO_2 max values by an average 16% (from 25.4 to 29.7 ml/kg/min), whereas the subjects in the control group increased their VO_2 max by a (nonsignificant) 2% (from 24.7 to 25.4 ml/kg/min).

Risk of bias in included studies

Results of the quality assessment can be found in the characteristics of included studies table and the additional table (Table 3).

The overall methodological quality score of the included studies ranged from 23 to 39 (minimum possible score of 14 points, maximum possible score of 48 points; lower scores denote a better methodological quality). In most of the trials the blinding procedures of the outcome assessors, treatment providers, and participants frequently scored “no, because blinding is not feasible”.
Cohen’s kappa (K) was calculated as a measure of inter-observer reliability after the initial screening by two reviewers (MA and GA) and reached 0.81, almost perfect according to Landis 1977.

Effects of interventions

Analyses on the effects of aerobic exercise on cognitive function compared to any other intervention rendered significant positive effects of aerobic exercise on cognitive speed (SMD random effects 0.26, 95% CI 0.04 to 0.48, P = 0.02) and visual attention (SMD random effects 0.26, 95% CI 0.02 to 0.49, P = 0.03). Analyses on the effects of aerobic exercise on cognitive function compared to no intervention (controls or waiting list groups) yielded significant positive effects of aerobic exercise on auditory attention (WMD random effects 0.52, 95% CI 0.13 to 0.91, P < 0.01) and motor function (WMD random effects 1.17, 95% CI 0.19 to 2.15, P = 0.02).
However, in the comparisons of exercise versus any intervention, nine of the 11 cognitive functions yielded no significant effects. Nine of the 11 cognitive functions showed no significant effects for exercise versus no intervention.
Analyses on the effects of aerobic exercise on cognition compared to a strength programme rendered no significant differences. However, these results should be interpreted with care since they were based on one study (Moul 1995). Analyses on the comparisons of aerobic exercise versus a social/mental programme included three studies (Emery 1990 a; Emery 1998; Fabre 2002). These comparisons were are not shown separately (data of the three were already pooled in the analysis of effects of aerobic exercise versus any intervention).

DISCUSSION

This review examined the effect of physical activity aimed at improving cardiorespiratory fitness on cognitive function in healthy older people without known cognitive impairment. The assumption being made is that improvements in cardiovascular (aerobic) fitness mediate benefits in cognitive capacity (Colcombe 2004; Kramer 1999; McAuley 2004). This would imply that a physically active lifestyle resulting in enhanced fitness could affect people’s cognitive abilities in the future and would enable them to partially influence their mental health.

Eight out of 11 studies in this review reported that aerobic exercise interventions resulted in increased cardiorespiratory fitness of the intervention group (an increase in VO_2 max of approximately 14%) and this improvement coincided with improvements in cognitive capacity, with effects observed for motor function, cognitive speed, auditory and visual attention.

However, there are issues that need further consideration.

Although aerobic exercise rendered significant effects on subcategories of cognition, the majority of comparisons yielded no significant results.

At the same time, choices regarding inclusion criteria and classification of cognitive tests into specific cognitive functions seem to have a profound effect on the results which renders the conclusions of this review (and other reviews on cognition) less transparent and limits the practical implementations of the results. Four meta-analytic studies published data based on very similar hypotheses yet failed to find comparable results:

- Etnier et al. (Etnier 1997 b) included 134 articles in their review. Four studies (Blumenthal 1989 a; Blumenthal 1989 b; Emery 1990 a; Madden 1989; Panton 1990) included in the present review were also included in Etnier's review, whereas, based on publication dates, six were possible (Moul and Whitehurst were not included in Etnier's review). The aim of the review conducted by Etnier and colleagues was to give a comprehensive overview of all literature available with sufficient information to calculate effect sizes. Therefore the review included, besides randomised controlled trials, several cross-sectional studies. This resulted in data on the acute effects of exercise and data of strength and flexibility regimens as well as results for younger age groups and cognitively impaired individuals. Cognition was categorised in terms of reasoning skills, verbal ability, memory, mathematical ability, creativity, motor skills, perception, IQ, dual task paradigms, reaction time and academic achievement. The authors concluded that exercise has a small positive effect on cognition and effect size depended on the exercise paradigm, the quality of the study, the participants and the cognitive tests used as outcome parameters.

- Heyn et al. (Heyn 2004) described the effects of exercise training on cognitive function in people with dementia and related cognitive impairments. "Cognitively impaired in any way" was an exclusion criterion in our review and therefore the results cannot be compared with those of Heyn et al. However, Heyn et al. concluded that exercise training increases fitness, physical function, positive behaviour and cognitive function (measured with MMSE) in people with dementia and related cognitive impairments.

- The meta-analysis presented by Colcombe and Kramer (Colcombe 2003) was based on 18 articles. Colcombe and Kramer searched Educational Research in Completion (ERIC), MEDLINE, PsycLIT and PsycINFO. Four studies (Emery 1990 a; Emery 1998; Madden 1989; Moul 1995) included in the present review were also included in Colcombe's review where, based on publication dates, it would have been possible to include the same articles in both reviews. Considering the aim of the meta-analysis ("to examine the hypothesis that aerobic fitness training enhances the cognitive vitality of healthy but sedentary older adults") and the exclusion criteria (cross-sectional design, no random assignment, unsupervised exercise programme, training lacking in fitness component and an average age below 55) this analysis could have resulted in similar results. Yet, we excluded five studies since they did not present a randomised controlled design but rather a quasi-randomised study (matched controls or assignment to intervention groups). Four studies were excluded from our review due to the fact that they did not present any fitness parameter and two studies provided no quantitative data. Furthermore, one study was excluded as the participants were cognitively impaired, one article provided the same data as Blumenthal et al. (Blumenthal 1989 a; Blumenthal 1989 b) which is included in our review and one study was excluded since participants suffered from depression (an exclusion criterion for our review). Colcombe and Kramer recoded all cognitive tasks into categories of speed (low-level neurological functioning), visuospatial (transforming or remembering visual and spatial information), controlled processes (tasks that require some cognitive control) or executive processes (related to planning, inhibition and scheduling of mental procedures) but do not give insight in the exact coding of the several cognitive tasks over the described categories. Colcombe and Kramer's review concluded that executive functions were significantly and positively related to increased physical activity. Moreover, Colcombe and Kramer stated that physical activity is beneficial for all other analysed cognitive functions.

- Just months after our search for articles, Etnier et al. (Etnier 2006) published their meta-analytic review on the relationship between aerobic fitness and cognitive performance. Their primary goal was "to provide a statistically powerful test of the viability of the cardiovascular fitness hypothesis by examining the dose-response relationship between aerobic fitness and cognition". Searching PubMeD, PsychINFO, Dissertation Abstracts International, Educational Research in Completion and Sports Discus rendered 30 studies which reported data on pre-post comparisons. Except for Bakken et al. (Bakken 2001), Blumenthal et al. (Blumenthal 1989 a; Blumenthal 1989 b), Hassmén and Koivula (Hassmén 1997 a; Hassmén 1997 b), Emery and Gatz (Emery 1990 a) and Panton et al. (Panton 1990), all of the remaining studies included in the present review were incorporated in the meta-analytic study by Etnier et al. as well. Etnier and colleagues included only those studies which assessed aerobic fitness by maximal, submaximal or a composite measure of fitness which included VO_2 max (lacking in Bakken et al. (Bakken 2001), Emery and Gatz (Emery 1990 a) and Hassmén and Koivula (Hassmén 1997 a; Hassmén 1997 b)), whereas we included all measures of aerobic fitness. At the same time, we imposed an age criterion and did not include studies on depressed participants whereas Etnier et al. included all ages and at least one study on depressed subjects. Finally, Etnier et al. included unpublished master theses and doctoral dissertations whereas we only included data published in peer reviewed journals. Etnier et al. recoded all cognitive measures into categories based upon Caroll's structure of cognitive abilities as derived from factor analysis (Caroll 1993) or test descriptions provided by Lezak (Lezak 2004). The following categories were discussed: fluid intelligence, crystallised intelligence, general memory and learning, visual perception, retrieval ability, speediness and processing speed. Post-test comparisons showed no significant relationships between aerobic fitness and cognitive performance. For the exercise groups the change in fitness from pre- to post-test was a significant linear predictor of the change in cognitive performance from pre- to post-test albeit in a negative direction. Age acted as a significant negative moderator variable in the relationship between aerobic fitness and cognition for older adults according to Etnier et al.

It is possible that engagement in aerobic physical activities accounts for improvements in short term cognitive capacities driven by physiological or psychological mechanisms other than aerobic fitness (Etnier 2006). This could explain why the positive effects of physical activity on cognition in longitudinal (Barnes 2003; Laurin 2001; Richards 2003; Sturman 2005; van Gelder 2004) and prospective studies (Abbott 2004; Yaffe 2001; Weuve 2004) are seldom demonstrated for all cognitive functions in randomised controlled trials. This might be another explanation for the incompatible results in the discussed meta-analyses. The relationship between physical activity and cognitive function could be modified by a number of (individual) factors other than cardiovascular function, which suggests that possible subgroups in the population could react differently on aerobic training and may show different effects on their cognitive performance across the age span. The search for possible subgroups has provided some promising results (examples in Podewils 2005; Etnier 2007; Schuit 2001) but more subgroups might have to be identified.

At the same time, there are indications that the intensity rather than duration of physical activities would be beneficial for cognition (Angevaren 2007; van Gelder 2004) which may have implications for the effectiveness of some of the training programmes in the included randomised controlled trials.

Processing current literature on physical activity and cognition led to a number of items which intrigued us that much that we felt is was necessary to present them as suggestions for future research.

Firstly, our review consists of results from as many as 33 different cognitive tests, already a smaller sample of tests than the absolute total reported in the included studies (tests were lost from analyses in order to avoid double representation of studies over the cognitive categories as well as the calculation of some summary combinations) but still a great number. A broad battery of tests would be in keeping with the reality in clinical settings and would give insight in the potential specificity of physical activity effects. At the same time, too great a number of cognitive tests used in a scientific setting might obstruct a general view on the intended effects. We recommend that all researchers in the field seek mutual agreement on a smaller battery of cognitive tests to use in order to render research on cognition transparent and heighten reproducibility of results. This smaller core-set of cognitive tests should incorporate cognitive measures of importance for scientific and clinical settings.

Secondly, if aerobic fitness is to act as an effective tool against age-related cognitive decline, the rate of change in cognitive performance over a significant period of time rather than the absolute short-term gain in performance immediately after the intervention would be relevant (as in Salthouse 2007). In this light, a limitation of training studies as used in the included randomised clinical trials is the lack of long-term monitoring (with an average duration of 14 weeks). The hypothesis that cardiovascular fitness would be beneficial as a tool which counteracts age-related cognitive decline would be supported if the differences between the trained subjects and the controls would increase as a function of age (Salthouse 2007). This proposition implies that future research should be directed at long-term intervention trials.

AUTHORS' CONCLUSIONS

Implications for practice

There is evidence that aerobic physical activities which improve cardiorespiratory fitness are beneficial for cognitive function in healthy older adults without known cognitive impairment, with effects observed for motor function, cognitive speed, auditory and visual attention. This benefit adds to the other known benefits of aerobic exercise.

Implications for research

The temporal association between improvements in cardiovascular fitness and in cognitive functions is suggestive of a causal link. Larger studies are still required to confirm whether the aerobic training component is necessary, or whether the same can be achieved with any type of physical exercise.

If such efficacy studies were to show that cardiovascular fitness achieved by aerobic exercise is necessary for cognitive improvement in the unimpaired elderly, then studies of effectiveness are needed. Specifically, longer studies are required to see whether the effect on cognitive function of brief programmes of aerobic exercise is sustained, or whether continued aerobic exercise is necessary. The clinical relevance and reproducibility of such data would be enhanced if clinicians and scientists in the field could agree upon the use of a smaller battery of cognitive tests.

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* *Indicates the major publication for the study*

C H A R A C T E R I S T I C S O F S T U D I E S

Characteristics of included studies *[ordered by study ID]*

Bakken 2001

Methods	Participants were not blinded. It is unclear whether the outcome assessor and care provider are blinded in this study. At randomisation 15 enrolled; 8 in the aerobic exercise group, 7 in the control group. Three participants were lost from the exercise condition, 2 were lost in the control group. No intention to treat analysis. Follow-up 8 weeks
Participants	10 participants (4 males, 6 females) in the age range of 72 to 91 years. Inclusion criteria: more than 65 years of age with no history of pulmonary disease, recurring falls, orthopaedic limitations or acute arthritis in the hands
Interventions	Aerobic exercise: 1 hour sessions for 3 sessions per week for 8 consecutive weeks. 10 minutes of warming up, aerobic conditioning period that increased in duration and intensity (callisthenics, walking and cycling) systematically each week, 10 minutes of cooling down. Subjects heart rates did not exceed the upper limit of their THRR* Control: continued their normal everyday routine, which did not include any aerobic exercise according to the subjects report
Outcomes	AI (Accuracy Index by finger tapping) Resting heart rate Resting systolic BP Resting rate-pressure product GXT test heart rate ** GXT test systolic BP GXT test RPP (Rate-Pressure product)
Notes	*THRR: (Karvonen) training HR = resting HR + [0.60-0.75 (HRR)]. HRR = age-predicted max HR - resting HR ** GXT: submaximal graded exercise tolerance test. Stage 1; stepping back and forth on the ground at a frequency of 20 mounts per minute for 3 minutes. Stage 2: stepping up and down a 10.16 cm high step. Stage 3: stepping up and down a 20.32 cm high step. Stage 4: stepping up and down a 30.48 cm high step. RPP; rate-pressure product = systolic BP multiplied by heart rate. A decrease in RPP is a quantitative measure of aerobic training

Risk of bias

Bias	Authors' judgement	Support for judgement
Allocation concealment?	Unclear risk	B - Unclear

Blumenthal 1989 a

Methods	101 participants (50 males and 51 females) were randomised either to aerobic exercise (N = 33), yoga/flexibility (N = 34) or control (N = 34). Two participants were lost from both the aerobic group and the control group. No intention to treat analysis. Patients were not blinded, it is unclear whether the care provider and the outcome assessor were blinded Follow up: 16 weeks
Participants	Participants (only the 51 females) aged 60 to 83 years Inclusion criteria: free from clinical manifestations of coronary disease assessed by medical history, physical examination, bicycle ergometry exercise testing. Exclusion criteria: positive ECG during exercise testing, evidence of coronary artery disease, asthma, pulmonectomy, uncontrolled hypertension, beta-blocker therapy
Interventions	Aerobic exercise: 3 supervised sessions for 16 weeks. Training based on 70% of max heart rate achieved on exercise test. 10 minutes of warming up, 30 minutes of bicycle ergometry, 15 minutes of brisk walking/jogging and arm ergometry, 5 minutes of cooling down. Yoga/flexibility: 2 supervised sessions a week for 60 minutes over 16 weeks. Controls: not to change their physical activity habits and especially not to engage in any aerobic exercise for the studyperiod
Outcomes	Tapping (dominant/non-dominant) Digit span (forward / backward) Benton Revised Visual Retention test (correct/error) Story Recall of the Randt Memory test (immediate) - data on the delayed Story Recall of the Randt Memory test could not be traced by the authors. Selective reminding test (total/intrusions) Trail making (part B) Digit Symbol substitution 2 & 7 test (digits/letters) Stroop colour word Stroop interference Verbal fluency Non-verbal fluency VO2 max AT
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Allocation concealment?	Unclear risk	B - Unclear

Blumenthal 1989 b

Methods	Details in Blumenthal 1989 a
Participants	Participants: only the 50 males Details in Blumenthal 1989 a
Interventions	Details in Blumenthal 1989 a
Outcomes	Details in Blumenthal 1989 a
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Allocation concealment?	Unclear risk	B - Unclear

Emery 1990 a

Methods	48 subjects (8 males and 40 females) were randomly assigned to an aerobic exercise programme (N = 15), social activity group (N = 15) or a control group (N = 18). One subject was lost from the aerobic group, 4 from the social group and 4 from the control group. No intention to treat analysis. The participants were not blinded, it is unclear whether the outcome assessor and the caregiver were blinded Follow-up: 12 weeks
Participants	48 participants aged 61 to 86 years. Inclusion criteria not described. Exclusion criteria not described.
Interventions	Exercise: 3 sessions per week for approximately 60 minutes. 10 to 15 minutes of stretching exercises followed by 20 to 25 minutes of aerobic exercise (at 70% of age-adjusted max = 220-age), including rapid walking as well as rhythmic muscle strengthening exercises (e.g. repeatedly standing up and sitting down) . 5 minutes of cooling down with dancing and light exercises. Social activity: 3 sessions per week for 60 minutes. Participation in non-physical activities (card games, art projects, political discussion groups, watching films). Controls: not described.
Outcomes	Digit Symbol substitution Digit Span Copying Words Copying Numbers (digit/sec) Weight (kg) Resting HR Resting blood pressure (syst/diast) BP during modified step test HR during modified step test Sit-and-reach test

Emery 1990 a (*Continued)*

Notes		
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Allocation concealment?	Unclear risk	B - Unclear

Emery 1998

Methods	Randomisation procedure: taken from a random number schedule. Participants were informed of their group assignment given by sealed envelopes after baseline testing. 79 participants (37 males and 42 females) were randomised: 29 in the aerobic exercise group, both 25 in the education group and control group. Four subjects were lost from the exercise condition, 2 from the education programme. Intention to treat was not performed. Patients were not blinded, whether the care provider and the assessors were blinded is unclear Follow-up: 10 weeks.
Participants	79 COPD patients of the age of 66.6 ± 6.5 enrolled. Inclusion criteria: aged over 50, FEV1 / FVC < .70 and clinical symptoms of COPD for more than 6 months. Exclusion criteria: significant cardiac disease during the previous 3 months or other medical conditions that would affect exercise tolerance or learning skills. Primarily acute, reversible airway disease (asthma) without fixed airflow obstruction. Tuberculosis, pulmonary fibrosis, cancer
Interventions	Exercise, education and stress management (EXESM): daily sessions for 4 hours a day during the initial 5-week period. 45 minutes of aerobic exercise as well as strength training on Nautilus equipment. 10 minutes of warming up, 35 minutes of aerobic exercise (cycling, arm ergometry, walking) and cooling down. Educational lectures on topics relevant for COPD patients. Weekly a 1 hour group meeting for stress management and psychological support. Following the first 5 weeks, EXESM participants followed a program of 3 sessions a week with 60 to 90 min of exercise and 1 hour a week of stress management. Thus, 37 exercise sessions, 16 educational sessions and 10 stress management classes in 10 weeks Education and stress management (ESM): 16 educational sessions and 10 stress management classes in 10 weeks Control: not to alter their physical activities during the study
Outcomes	Digit vigilance test Finger tapping Trailmaking (part A and B) Digit symbol substitution Verbal fluency VO2 max HR max Workload max

Emery 1998 *(Continued)*

Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Allocation concealment?	Low risk	A - Adequate

Fabre 2002

Methods	32 participants (5 males and 27 females) at randomisation; each group (physical training, memory training, combined physical/memory training and controls) contained 8 subjects. All the participants completed the study and intention to treat analysis was not necessary. Patients were not blinded, it is unclear whether the assessor and the care provider were blinded Follow-up: 2 months
Participants	32 participants in the age range of 60 to 76 years. Inclusion criteria are not described. Exclusion criteria: positive ECG during exercise testing, present depression, could not breathe through the tube during exercise testing, various other reasons such as disease during training
Interventions	Physical training: two supervised 1 hour exercise sessions per week for 2 months: walking and running to maintain target heart rate (target heart rate corresponded to the ventilatory threshold). 5 minutes of warming up, 45 minutes of walking/running, 10 minutes of cooling down Memory training: 90 minutes of sessions once a week for 8 weeks. 15 minutes of explaining, Israel's method in core Combined physical training and memory training. Controls; no training whatsoever.
Outcomes	Memory quotient (= total score of al WAIS subtests) Paired associates learning Digit span forward Logical memory immediate recall Orientation General information Mental control Visual reproductions VO2 max VO2 max at Vth Max O2 pulse Max O2 pulse at Vth
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement

Fabre 2002 (*Continued)*

Allocation concealment?	Unclear risk	B - Unclear

Hassmén 1997 a

Methods	40 participants (20 males and 20 females) were matched in pairs (according to sex, age, cognitive results and heart rate response) and one of each pair was randomly assigned to the exercise group. 20 participants per group, no one was lost to follow-up and intention to treat was not necessary. Patients were not blinded, it is unclear whether the outcome assessor and the care provider were blinded Follow-up: 3 months
Participants	20 female participants, aged 55 to 75 years. Inclusion criteria: free from medical conditions or impairment (according to self-ratings) and did not use medication in the past six months. Furthermore, the participants were sedentary (did not take part in any form of regular physical exercise)
Interventions	Exercise group: regular walking exercise 3 times a week during three months with intensities according to RPEs (Borg scale) of 9 (very light), 11 (fairly light) and 13 (somewhat hard). The performed exercise gave rise to heart rate responses of 95 to 125 beats/min. Control group: the members were given home assignments to be performed 3 times per week
Outcomes	Simple RT (min) Choice RT (min) Immediate recall Delayed Recall Face recognition Digit Span Heart rate (beats/min) RPE
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Allocation concealment?	Unclear risk	B - Unclear

Hassmén 1997 b

Methods	Details in Hassmén 1997 a
Participants	20 male participants Details in Hassmén 1997 a
Interventions	Details in Hassmén 1997 a
Outcomes	Details in Hassmén 1997 a

Hassmén 1997 b (*Continued)*

Notes		
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Allocation concealment?	Unclear risk	B - Unclear

Kramer 2001

Methods	174 participants at randomisation. Subsequently 50 subjects were dropped from the study because of withdrawal from the training protocol or incomplete data. The study was completed by 124 individuals; 58 (13 men) in the aerobic group and 66 (20 men) in the stretching and toning group. No Intention to treat analysis. Participants were not blinded, it is unclear whether the care provider and the assessor were blinded Follow-up period: 6 months.
Participants	124 participants aged 60 to 75 years of age. Inclusion criteria: aged 60 to 75 years, sedentary (no physical activity in the preceeding 6 months), capable of performing exercise, physicians examination and consent to participate, successful completion of graded exercise test without evidence of cardiac abnormalities, initial depression score on the GDS below clinical level, no history of neurologic disorders, corrected (near & far) acuity of 20/40 or better, fewer than three errors on the Pfeiffer Mental Status questionnaire. Exclusion criteria: younger than 60 years, self-reported activity on a regular basis (2 times a week) in the preceeding 6 months, any physical disability that prohibits mobility, non-consent of physician, evidence of abnormal cardiac responses during graded exercise testing, depression score on the GDS indicative of clinical depression, history of neurologic disorders, corrected (near & far) acuity greater than 20/40, more than three errors on the Pfeiffer questionnaire
Interventions	Aerobic walking exercise: 3 supervised sessions per week for 6 months. Warming up, 40 minutes of brisk walking (gradually beginning at 10 to 15 minutes up to 40 minutes), cooling down. Initial exercise was performed at 50 to 55% of VO2 max and increased to 65 to 70% of VO2 max Stretching and toning: 3 times a week supervised sessions for 6 months. The program emphasized stretches for all the large muscle group of the upper and lower extremities. Each stretch was held for 20 to 30 seconds and repeated 5 to 10 times. Each session was preceeded and followed by 10 minutes of warm-up and cooling down
Outcomes	Visual search task Response compatibility task Task switching paradigm Stopping paradigm Spatial attention task Rey auditory verbal learning test Pursuit rotor task Self-ordered pointing task Spatial working memory Verbal working memory Face recognition task

Kramer 2001 *(Continued)*

	Digit-digit and digit-symbol tests Forward and backward digit span VO2 max (ml/kg/min) Time on treadmill (min) Rockport 1-mile walk (min)
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Allocation concealment?	Unclear risk	B - Unclear

Madden 1989

Methods	85 participants (44 males and 41 females) at randomisation; 28 in the aerobic group, 30 in the yoga group and 27 served as controls. Three participants were lost from the exercise group, 2 from the yoga group and 1 from the controls. No intention to treat analysis. Participants were not blinded, it is unclear whether the care provider and the assessor are blinded Follow-up: 16 weeks.
Participants	Participants were 60 to 83 years of age. Inclusion criteria: free of medical conditions that would preclude a programme of either aerobic exercise or yoga Exclusion criteria: uncontrolled hypertension, diabetes, or coronary heart disaese, use of beta-blockers or psychotropic medication
Interventions	Aerobic exercise: 3 supervised sessions per week for 16 weeks. 10 minutes of warming up, 30 minutes of cycling, 15 minutes of brisk walking and/or jogging, 5 minutes of cooling down. All exercise was performed in target (training) heart range (70% of max during initial exercise test) Yoga: 2 a week 60 minutes supervised yoga sessions for 16 weeks Control: no change to their physical activity habits for the length of the study
Outcomes	Letter search RT task (short-term memory) Word comparison RT task (long-term memory) VO2 max
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Allocation concealment?	Unclear risk	B - Unclear

Moul 1995

Methods	30 participants (11 males, 19 females), the walking, weight training and control group all contained 10 participants. Participants were not blinded; it is unclear whether the outcome assessor and the caregiver were blinded. No participants were lost to follow-up, intention to treat analysis was not necessary Follow-up: 16 weeks.
Participants	30 participants aged 65 to 72 years. Inclusion criteria: nondiseased (no current symptoms or signs suggestive of heart disease), nonactive (defined as < 2 moderate to vigorous aerobic or resistance training sessions of > 20 minutes per week)
Interventions	Walking: 5 sessions per week. Walking 30 minutes at 60% of HRR (as determined by treadmill testing) . Walking duration was increased 2 minutes per week until they reached 40 minutes and HRR were adjusted after 8 weeks of training to 65% of HRR Weight training: 5 sessions per week of upper and lower body exercises on alternate days of the week. Abdominal crunches and back extensions were performed in each session. Weight group employed a daily adjusted progressive resistive exercise programme (DAPRE) using weights Controls: 5 sessions per week mild stretching exercises for 30 to 40 minutes. Minimal challenge to the cardiovascular or muscular systems
Outcomes	Immediate Memory (Ross Information Processing Assessment) Recent Memory (RIPA) Temporal Orientation (RIPA) Problem Solving and abstract reasoning (RIPA) Organization (RIPA) Auditory Processing (RIPA) Weight (kg) Sum of seven skinfolds (mm) VO2 max (ml/kg/min) Time on treadmill (min) Ventilation (ml/min) RER Knee extension (lb) Elbow flexion (lb)
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Allocation concealment?	Unclear risk	B - Unclear

Panton 1990

Methods	57 participants were randomised in a walk/jog group, a strength group and a control group. Eight participants were lost to follow-up; it is unclear from which condition these subjects were lost. Intention to treat analysis was not performed. Analyses were performed on 17 participants in the walk/jog group, 20 subjects in the strength group and 12 controls. Participants were not blinded; it is unclear whether the outcome assessor and the caregiver were blinded Follow-up: 26 weeks.
Participants	Participants were retired professionals from the university community of Gainesville, FL and 70 to 79 years of age. Inclusion criteria: sedentary non-smokers who had no contraindications to exercise testing or training. Free of any overt evidence of coronary artery disease and other conditions that would limit their participation in a vigorous exercise programme (as tested with a diagnostic graded exercise test (using a modified Naughton protocol). Exclusion criteria werer not described.
Interventions	The walk/jog group participated in three exercise sessions per week for the duration of the study. All training sessions were preceded by 5 to 10 minutes of stretching and warm-up and ended with 5 min of cool-down exercises. Initially, participants started walking/jogging for 20 minutes at 50% of their maximal heart rate reserve (HRRmax). The duration was increased by 5 min every 2 weeks until the subjects walked for 40 minutes. Training intensity was gradually increased until subjects could walk at 60 to 70% of their HRRmax. During the 14th week of training exercise intensity was further increased by alternating fast walk/moderate walk or fast walk/slow jog intervals. Five participants increased their training intensity by increasing the slope of the treadmill. By the 26th week of training, all subjects performed at 85% of HRRmax for 35 to 45 min. Subjects in the strength group participated in 30 min sessions, 3 times a week for 26 weeks. Workouts consisted of one set of 10 variable resistance Nautilus exercises (leg, arm and torso muscles). During the first 13 weeks, subjects used light to moderate weights and performed 8 to 12 repetitions for each exercise. During the last 13 weeks, resistance was increased substantially and subjects were encouraged to train to volitional muscular fatigue. When subjects could complete 12 or more repetitions, the resistance was increased. Participants in the control group were asked not to change their lifestyle over the 6 month duration of the study
Outcomes	Total simple Reaction time Fractionated Reaction time (PreMotorTime and MotorTime) Speed of Movement measurements Fat percentage (predicted from body density) Body density (7 skinfolds) 1RM muscle strength test VO2max
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Allocation concealment?	Unclear risk	B - Unclear

Whitehurst 1991

Methods	14 participants at randomisation (all females): 7 in both the exercise and the control group. All the subjects completed the study, intention to treat analysis was not necessary. Participants were not blinded, it is unclear whether the care provider and the assessor were blinded Follow-up: 8 weeks.
Participants	Females in the age range of 61 to 73 years. Inclusion criteria: did not participate in aerobic exercise more than one time per week prior to the study. Medical clearance from a physician (resting ECG and physical examination). Free of primary cardiovascular risk factors. Maintained the household
Interventions	Exercise: 3 supervised sessions per week for 8 weeks (total of 24 sessions). 5 to 10 minutes of warming up and cooling down. The subjects cycled for 8 to 10 minutes the first week to provide acclimatization. Thereafter, 3 to 5 minutes was added to subsequent sessions so that by week 4 all subjects were cycling for 35 to 40 minutes at their target heart rate Control: did not engage in any form of vigorous physical activity during the course of the study
Outcomes	Simple reaction time Choice reaction time Estimated VO2 max
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Allocation concealment?	Unclear risk	B - Unclear

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Barry 1966	Not RCT but CCT.
Blumenthal 1988	Participants were to young to meet the given inclusion criteria of this review
Blumenthal 1991	Data were already published in Blumenthal 1989.
Dietrich 2004	Data could not test the cardiovascular fitness hypothesis since cognition was assessed during exercise
Dustman 1984	No RCT but quasi-randomised study (participants "alternately assigned")
Emery 1990 b	Perceived (subjective) measurements of cognition were analysed according to groups but the objective measures of cognition were analysed according to perceived measures of cognition

(*Continued*)

Emery 2003	Within subjects repeated measures design to evaluate the influence of music and exercise on cognition. No control group
Etnier 1997 a	No exercise intervention.
Etnier 2001	The control group was encouraged to continue exercising; however no formal program was provided
Fabre 1999	No means and SDs for cognitive data. These results are described in Fabre2001
Hassmén 1992	No RCT but 'matched controls'.
Hawkins 1992	No fitness parameter present.
Hill 1993	No RCT but quasi-randomised study (participants "assigned to intervention group")
Kerschan 2002	Both groups followed aerobic training intervention.
Kharti 2001	Study participants were depressed older men and women: depression was an exclusion criterion for our review
Kramer 1999	This article provides no quantitative data on which an analysis can be based. Quantitative data of the RCT of this research group is provided in Kramer 2001, which is included in our review
Molloy 1988	Exercise was not intended to improve aerobic fitness.
Oken 2004	Participants were too young to meet the given inclusion criteria of this review
Okumiya 1996	No fitness parameter present.
Palleschi 1996	Participants were elderly patients with senile dementia of the Alzheimer type: this was an exclusion criterion for our review
Perri 1984	Not a true RCT but a clinical trial
Pierce 1993	Participants were too young to meet the given inclusion criteria of this review
Powell 1974	Narrative review; this article provides no quantitative data
Rikli 1991	Balance, sit and reach flexibility, shoulder flexibility, and grip strength were given as fitness parameters. We did not include this RCT since neither of the two fitness parameters reflect aerobic fitness
Stevenson 1990	Both intervention groups recieved aerobic training (different levels of intensity)
Wallman 2004	Participants were too young to meet the given inclusion criteria of this review
Wilbur 2005	No objective measures of cognitive parameters (symptom impact inventory)
Williams 1997	No objective measures of fitness, only subjective measures (Percieved General Fitness)

DATA AND ANALYSES

Comparison 1. Aerobic exercise vs. any intervention

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Cognitive speed	6	312	Std. Mean Difference (IV, Random, 95% CI)	0.24 [0.01, 0.46]
1.1 Simple reaction time	1	37	Std. Mean Difference (IV, Random, 95% CI)	-0.10 [-0.75, 0.54]
1.2 Choice reaction time	0	0	Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
1.3 Trailmaking part A	1	48	Std. Mean Difference (IV, Random, 95% CI)	0.52 [-0.06, 1.10]
1.4 Digit symbol substitution	4	227	Std. Mean Difference (IV, Random, 95% CI)	0.23 [-0.03, 0.50]
2 Verbal memory functions (immediate)	4	209	Std. Mean Difference (IV, Random, 95% CI)	0.17 [-0.10, 0.44]
2.1 Randt Memory test story recall	2	65	Std. Mean Difference (IV, Random, 95% CI)	0.33 [-0.16, 0.82]
2.2 16 words immediate recall	0	0	Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
2.3 Ross Information Processing Assessment immediate memory	1	20	Std. Mean Difference (IV, Random, 95% CI)	0.06 [-0.82, 0.93]
2.4 Wechsler Adult Intelligence Scales logical memory immediate recall	0	0	Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
2.5 Rey auditory verbal learning trial I-V	1	124	Std. Mean Difference (IV, Random, 95% CI)	0.10 [-0.25, 0.45]
3 Visual memory functions (immediate)	2	65	Mean Difference (IV, Fixed, 95% CI)	0.04 [-1.66, 1.75]
3.1 Benton visual retention (# error)	2	65	Mean Difference (IV, Fixed, 95% CI)	0.04 [-1.66, 1.75]
3.2 Wechsler Memory Scales visual reproduction	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
4 Working memory	3	189	Mean Difference (IV, Random, 95% CI)	0.36 [-0.31, 1.03]
4.1 Digit span backward	3	189	Mean Difference (IV, Random, 95% CI)	0.36 [-0.31, 1.03]
5 Memory functions (delayed)	1	124	Mean Difference (IV, Fixed, 95% CI)	0.5 [-0.44, 1.44]
5.1 16 words delayed recall	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
5.2 Rey auditory verbal learning delayed recall trial	1	124	Mean Difference (IV, Fixed, 95% CI)	0.5 [-0.44, 1.44]
6 Executive functions	7	326	Std. Mean Difference (IV, Random, 95% CI)	0.16 [-0.20, 0.51]
6.1 Trailmaking part B	2	65	Std. Mean Difference (IV, Random, 95% CI)	0.35 [-0.14, 0.85]
6.2 Ross Information Processing Assessment problem solving and abstract reasoning	1	20	Std. Mean Difference (IV, Random, 95% CI)	-0.88 [-1.81, 0.05]
6.3 Wechsler Memory Scales mental control	1	16	Std. Mean Difference (IV, Random, 95% CI)	-0.44 [-1.44, 0.55]
6.4 Word comparison (#error)	1	53	Std. Mean Difference (IV, Random, 95% CI)	0.24 [-0.30, 0.78]
6.5 Task switching paradigm (accuracy)	1	124	Std. Mean Difference (IV, Random, 95% CI)	0.03 [-0.32, 0.38]
6.6 Verbal fluency	1	48	Std. Mean Difference (IV, Random, 95% CI)	0.87 [0.28, 1.47]
7 Perception	3	160	Std. Mean Difference (IV, Random, 95% CI)	-0.10 [-0.63, 0.43]

7.1 Face recognition (delayed recall)	1	124	Std. Mean Difference (IV, Random, 95% CI)	0.17 [-0.18, 0.53]
7.2 Ross Information Processing Assessment auditory processing	1	20	Std. Mean Difference (IV, Random, 95% CI)	-0.17 [-1.05, 0.71]
7.3 Wechsler Adult Intelligence Scales visual reproduction	1	16	Std. Mean Difference (IV, Random, 95% CI)	-0.81 [-1.84, 0.22]
8 Cognitive inhibition	3	189	Std. Mean Difference (IV, Random, 95% CI)	-0.02 [-0.31, 0.26]
8.1 Stroop color word (interference)	2	65	Std. Mean Difference (IV, Random, 95% CI)	-0.07 [-0.56, 0.42]
8.2 Stopping task (accuracy choice RT)	1	124	Std. Mean Difference (IV, Random, 95% CI)	0.01 [-0.35, 0.36]
9 Visual attention	5	290	Std. Mean Difference (IV, Random, 95% CI)	0.26 [0.02, 0.49]
9.1 Digit vigilance	1	48	Std. Mean Difference (IV, Random, 95% CI)	0.45 [-0.13, 1.02]
9.2 Tracking (accuracy index)	0	0	Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
9.3 2&7 test	2	65	Std. Mean Difference (IV, Random, 95% CI)	0.30 [-0.19, 0.79]
9.4 Letter search primary task RT	1	53	Std. Mean Difference (IV, Random, 95% CI)	0.05 [-0.49, 0.59]
9.5 Visual search (accuracy)	1	124	Std. Mean Difference (IV, Random, 95% CI)	0.25 [-0.10, 0.60]
10 Auditory attention	5	243	Mean Difference (IV, Random, 95% CI)	0.05 [-0.45, 0.54]
10.1 Digit span forward	5	243	Mean Difference (IV, Random, 95% CI)	0.05 [-0.45, 0.54]
11 Motor function	4	237	Std. Mean Difference (IV, Random, 95% CI)	0.52 [-0.25, 1.30]
11.1 Finger tapping	3	113	Std. Mean Difference (IV, Random, 95% CI)	0.72 [-0.35, 1.78]
11.2 Pursuit rotor task (tracking error)	1	124	Std. Mean Difference (IV, Random, 95% CI)	0.02 [-0.33, 0.38]

Comparison 2. Aerobic exercise vs. no intervention

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Cognitive speed	8	236	Std. Mean Difference (IV, Random, 95% CI)	0.10 [-0.16, 0.36]
1.1 Simple reaction time	1	29	Std. Mean Difference (IV, Random, 95% CI)	0.02 [-0.71, 0.76]
1.2 Choice reaction time	3	54	Std. Mean Difference (IV, Random, 95% CI)	-0.38 [-0.93, 0.16]
1.3 Trailmaking part A	1	50	Std. Mean Difference (IV, Random, 95% CI)	0.08 [-0.47, 0.64]
1.4 Digit symbol substitution	3	103	Std. Mean Difference (IV, Random, 95% CI)	0.38 [-0.02, 0.78]
2 Verbal memory functions (immediate)	6	141	Std. Mean Difference (IV, Random, 95% CI)	0.06 [-0.30, 0.42]
2.1 Randt Memory test story recall	2	65	Std. Mean Difference (IV, Random, 95% CI)	-0.05 [-0.54, 0.44]
2.2 16 words immediate recall	2	40	Std. Mean Difference (IV, Random, 95% CI)	-0.11 [-0.73, 0.51]
2.3 Ross Information Processing Assessment immediate memory	1	20	Std. Mean Difference (IV, Random, 95% CI)	1.14 [0.18, 2.10]
2.4 Wechsler Adult Intelligence Scales logical memory immediate recall	1	16	Std. Mean Difference (IV, Random, 95% CI)	-0.22 [-1.21, 0.76]

2.5 Rey auditory verbal learning trial I-V	0	0	Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
3 Visual memory functions (immediate)	3	81	Std. Mean Difference (IV, Random, 95% CI)	-0.15 [-0.58, 0.29]
3.1 Benton visual retention (# error)	2	65	Std. Mean Difference (IV, Random, 95% CI)	-0.07 [-0.56, 0.42]
3.2 Wechsler Memory Scales visual reproduction	1	16	Std. Mean Difference (IV, Random, 95% CI)	-0.46 [-1.45, 0.54]
4 Working memory	2	65	Mean Difference (IV, Fixed, 95% CI)	0.49 [-0.76, 1.73]
4.1 Digit span backward	2	65	Mean Difference (IV, Fixed, 95% CI)	0.49 [-0.76, 1.73]
5 Memory functions (delayed)	2	40	Mean Difference (IV, Fixed, 95% CI)	-0.55 [-2.11, 1.00]
5.1 16 words delayed recall	2	40	Mean Difference (IV, Fixed, 95% CI)	-0.55 [-2.11, 1.00]
5.2 Rey auditory verbal learning delayed recall trial	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
6 Executive functions	6	202	Std. Mean Difference (IV, Random, 95% CI)	0.23 [-0.09, 0.56]
6.1 Trailmaking part B	2	65	Std. Mean Difference (IV, Random, 95% CI)	0.04 [-0.45, 0.53]
6.2 Ross Information Processing Assessment problem solving and abstract reasoning	1	20	Std. Mean Difference (IV, Random, 95% CI)	1.08 [0.13, 2.03]
6.3 Wechsler Memory Scales mental control	1	16	Std. Mean Difference (IV, Random, 95% CI)	-0.19 [-1.17, 0.79]
6.4 Word comparison (#error)	1	51	Std. Mean Difference (IV, Random, 95% CI)	0.05 [-0.50, 0.60]
6.5 Task switching paradigm (accuracy)	0	0	Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
6.6 Verbal fluency	1	50	Std. Mean Difference (IV, Random, 95% CI)	0.51 [-0.06, 1.07]
7 Perception	4	76	Std. Mean Difference (IV, Random, 95% CI)	0.10 [-0.38, 0.57]
7.1 Face recognition (delayed recall)	2	40	Std. Mean Difference (IV, Random, 95% CI)	0.13 [-0.60, 0.86]
7.2 Ross Information Processing Assessment auditory processing	1	20	Std. Mean Difference (IV, Random, 95% CI)	0.48 [-0.41, 1.38]
7.3 Wechsler Adult Intelligence Scales visual reproduction	1	16	Std. Mean Difference (IV, Random, 95% CI)	-0.46 [-1.45, 0.54]
8 Cognitive inhibition	2	65	Mean Difference (IV, Fixed, 95% CI)	2.47 [-0.62, 5.55]
8.1 Stroop color word (interference)	2	65	Mean Difference (IV, Fixed, 95% CI)	2.47 [-0.62, 5.55]
8.2 Stopping task (accuracy choice RT)	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
9 Visual attention	5	176	Std. Mean Difference (IV, Random, 95% CI)	0.09 [-0.20, 0.39]
9.1 Digit vigilance	1	50	Std. Mean Difference (IV, Random, 95% CI)	-0.08 [-0.64, 0.47]
9.2 Tracking (accuracy index)	1	10	Std. Mean Difference (IV, Random, 95% CI)	0.76 [-0.55, 2.07]
9.3 2&7 test	2	65	Std. Mean Difference (IV, Random, 95% CI)	0.04 [-0.45, 0.52]
9.4 Letter search primary task RT	1	51	Std. Mean Difference (IV, Random, 95% CI)	0.23 [-0.32, 0.78]
9.5 Visual search (accuracy)	0	0	Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
10 Auditory attention	5	121	Mean Difference (IV, Random, 95% CI)	0.52 [0.13, 0.91]
10.1 Digit span forward	5	121	Mean Difference (IV, Random, 95% CI)	0.52 [0.13, 0.91]
11 Motor function	3	115	Mean Difference (IV, Random, 95% CI)	1.17 [0.19, 2.15]
11.1 Finger tapping	3	115	Mean Difference (IV, Random, 95% CI)	1.17 [0.19, 2.15]

11.2 Pursuit rotor task (tracking error)	0	0	Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]

Comparison 3. Aerobic exercise vs. flexibility / balance programme

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Cognitive speed	3	189	Mean Difference (IV, Random, 95% CI)	1.29 [-0.41, 2.98]
1.1 Simple reaction time	0	0	Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
1.2 Choice reaction time	0	0	Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
1.3 Trailmaking part A	0	0	Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
1.4 Digit symbol substitution	3	189	Mean Difference (IV, Random, 95% CI)	1.29 [-0.41, 2.98]
2 Verbal memory functions (immediate)	3	189	Std. Mean Difference (IV, Random, 95% CI)	0.18 [-0.11, 0.47]
2.1 Randt Memory test story recall	2	65	Std. Mean Difference (IV, Random, 95% CI)	0.33 [-0.16, 0.82]
2.2 16 words immediate recall	0	0	Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
2.3 Ross Information Processing Assessment immediate memory	0	0	Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
2.4 Wechsler Adult Intelligence Scales logical memory immediate recall	0	0	Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
2.5 Rey auditory verbal learning trial I-V	1	124	Std. Mean Difference (IV, Random, 95% CI)	0.10 [-0.25, 0.45]
3 Visual memory functions (immediate)	2	65	Mean Difference (IV, Fixed, 95% CI)	0.04 [-1.66, 1.75]
3.1 Benton visual retention (# error)	2	65	Mean Difference (IV, Fixed, 95% CI)	0.04 [-1.66, 1.75]
3.2 Wechsler Memory Scales visual reproduction	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
4 Working memory	3	189	Mean Difference (IV, Random, 95% CI)	0.36 [-0.31, 1.03]
4.1 Digit span backward	3	189	Mean Difference (IV, Random, 95% CI)	0.36 [-0.31, 1.03]
5 Memory functions (delayed)	1	124	Mean Difference (IV, Fixed, 95% CI)	0.5 [-0.44, 1.44]
5.1 16 words delayed recall	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
5.2 Rey auditory verbal learning delayed recall trial	1	124	Mean Difference (IV, Fixed, 95% CI)	0.5 [-0.44, 1.44]
6 Executive functions	4	242	Std. Mean Difference (IV, Random, 95% CI)	0.16 [-0.09, 0.41]
6.1 Trailmaking part B	2	65	Std. Mean Difference (IV, Random, 95% CI)	0.35 [-0.14, 0.85]
6.2 Ross Information Processing Assessment problem solving and abstract reasoning	0	0	Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
6.3 Wechsler Memory Scales mental control	0	0	Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
6.4 Word comparison (#error)	1	53	Std. Mean Difference (IV, Random, 95% CI)	0.24 [-0.30, 0.78]
6.5 Task switching paradigm (accuracy)	1	124	Std. Mean Difference (IV, Random, 95% CI)	0.03 [-0.32, 0.38]
6.6 Verbal fluency	0	0	Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]

7 Perception	1	124	Mean Difference (IV, Fixed, 95% CI)	3.70 [-3.68, 11.08]
7.1 Face recognition (delayed recall)	1	124	Mean Difference (IV, Fixed, 95% CI)	3.70 [-3.68, 11.08]
7.2 Ross Information Processing Assessment auditory processing	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
7.3 Wechsler Adult Intelligence Scales visual reproduction	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
8 Cognitive inhibition	3	189	Std. Mean Difference (IV, Random, 95% CI)	-0.02 [-0.31, 0.26]
8.1 Stroop color word (interference)	2	65	Std. Mean Difference (IV, Random, 95% CI)	-0.07 [-0.56, 0.42]
8.2 Stopping task (accuracy choice RT)	1	124	Std. Mean Difference (IV, Random, 95% CI)	0.01 [-0.35, 0.36]
9 Visual attention	4	242	Std. Mean Difference (IV, Random, 95% CI)	0.22 [-0.03, 0.47]
9.1 Digit vigilance	0	0	Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
9.2 Tracking (accuracy index)	0	0	Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
9.3 2&7 test	2	65	Std. Mean Difference (IV, Random, 95% CI)	0.30 [-0.19, 0.79]
9.4 Letter search primary task RT	1	53	Std. Mean Difference (IV, Random, 95% CI)	0.05 [-0.49, 0.59]
9.5 Visual search (accuracy)	1	124	Std. Mean Difference (IV, Random, 95% CI)	0.25 [-0.10, 0.60]
10 Auditory attention	3	189	Mean Difference (IV, Random, 95% CI)	-0.20 [-0.81, 0.40]
10.1 Digit span forward	3	189	Mean Difference (IV, Random, 95% CI)	-0.20 [-0.81, 0.40]
11 Motor function	3	189	Std. Mean Difference (IV, Random, 95% CI)	0.07 [-0.21, 0.36]
11.1 Finger tapping	2	65	Std. Mean Difference (IV, Random, 95% CI)	0.17 [-0.31, 0.66]
11.2 Pursuit rotor task (tracking error)	1	124	Std. Mean Difference (IV, Random, 95% CI)	0.02 [-0.33, 0.38]

Comparison 4. Aerobic exercise vs. strength programme

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Verbal memory functions (immediate)	1	20	Mean Difference (IV, Fixed, 95% CI)	0.30 [-4.17, 4.77]
1.1 Randt Memory test story recall	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
1.2 16 words immediate recall	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
1.3 Ross Information Processing Assessment immediate memory	1	20	Mean Difference (IV, Fixed, 95% CI)	0.30 [-4.17, 4.77]
1.4 Wechsler Adult Intelligence Scales logical memory immediate recall	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
1.5 Rey auditory verbal learning trial I-V	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
2 Executive functions	1	20	Mean Difference (IV, Fixed, 95% CI)	-2.30 [-4.49, -0.11]
2.1 Trailmaking part B	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

2.2 Ross Information Processing Assessment problem solving and abstract reasoning	1	20	Mean Difference (IV, Fixed, 95% CI)	-2.30 [-4.49, -0.11]
2.3 Wechsler Memory Scales mental control	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
2.4 Word comparison (#error)	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
2.5 Task switching paradigm (accuracy)	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
2.6 Verbal fluency	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
3 Perception	1	20	Mean Difference (IV, Fixed, 95% CI)	-0.5 [-2.93, 1.93]
3.1 Face recognition (delayed recall)	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
3.2 Ross Information Processing Assessment auditory processing	1	20	Mean Difference (IV, Fixed, 95% CI)	-0.5 [-2.93, 1.93]
3.3 Wechsler Adult Intelligence Scales visual reproduction	0	0	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

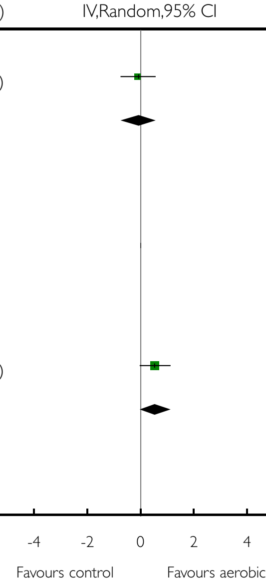
Analysis 1.1. Comparison 1 Aerobic exercise vs. any intervention, Outcome 1 Cognitive speed.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 1 Aerobic exercise vs. any intervention

Outcome: 1 Cognitive speed

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Simple reaction time							
Panton 1990	17	-274 (28.9)	20	-270 (44.7)		12.1 %	-0.10 [-0.75, 0.54]
Subtotal (95% CI)	**17**		**20**			**12.1 %**	**-0.10 [-0.75, 0.54]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.31 (P = 0.76)							
2 Choice reaction time							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
3 Trailmaking part A							
Emery 1998	25	-33.5 (9.7)	23	-40.5 (16.2)		15.2 %	0.52 [-0.06, 1.10]
Subtotal (95% CI)	**25**		**23**			**15.2 %**	**0.52 [-0.06, 1.10]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.77 (P = 0.077)							



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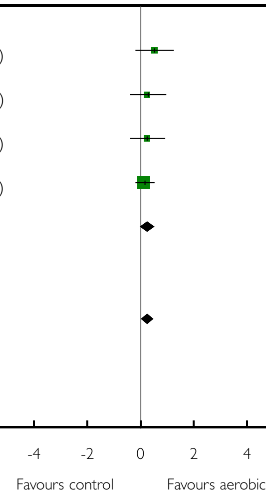
Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
4 Digit symbol substitution							
Blumenthal 1989 a	15	54.6 (8.6)	17	49.2 (11.3)		10.1 %	0.52 [-0.19, 1.23]
Blumenthal 1989 b	16	50.5 (9.3)	17	48.1 (8.5)		10.7 %	0.26 [-0.42, 0.95]
Emery 1990 a	14	35.8 (12.6)	24	32.9 (11.3)		11.5 %	0.24 [-0.42, 0.90]
Kramer 2001	58	96.5 (3.88)	66	95.7 (6.34)		40.4 %	0.15 [-0.20, 0.50]
Subtotal (95% CI)	**103**		**124**			**72.8 %**	**0.23 [-0.03, 0.50]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.86$, df = 3 (P = 0.84); $I^2 = 0.0\%$							
Test for overall effect: Z = 1.73 (P = 0.085)							
Total (95% CI)	**145**		**167**			**100.0 %**	**0.24 [0.01, 0.46]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 2.84$, df = 5 (P = 0.72); $I^2 = 0.0\%$							
Test for overall effect: Z = 2.05 (P = 0.040)							



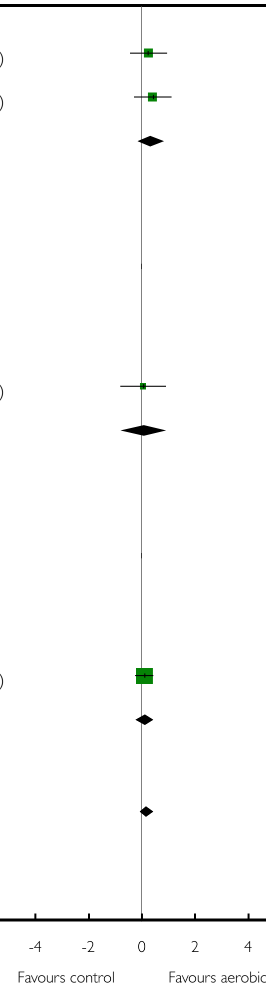
Analysis 1.2. Comparison 1 Aerobic exercise vs. any intervention, Outcome 2 Verbal memory functions (immediate).

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 1 Aerobic exercise vs. any intervention

Outcome: 2 Verbal memory functions (immediate)

Study or subgroup	Treatment N	Treatment Mean(SD)	Control N	Control Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Randt Memory test story recall							
Blumenthal 1989 a	15	10.7 (3.6)	17	9.8 (3.5)		15.3 %	0.25 [-0.45, 0.94]
Blumenthal 1989 b	16	11.4 (4.1)	17	9.8 (3.4)		15.5 %	0.42 [-0.28, 1.11]
Subtotal (95% CI)	**31**		**34**			**30.8 %**	**0.33 [-0.16, 0.82]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.11$, df = 1 (P = 0.74); I^2 =0.0%							
Test for overall effect: Z = 1.33 (P = 0.18)							
2 16 words immediate recall							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
3 Ross Information Processing Assessment immediate memory							
Moul 1995	10	23.5 (3.5)	10	23.2 (6.3)		9.7 %	0.06 [-0.82, 0.93]
Subtotal (95% CI)	**10**		**10**			**9.7 %**	**0.06 [-0.82, 0.93]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.13 (P = 0.90)							
4 Wechsler Adult Intelligence Scales logical memory immediate recall							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
5 Rey auditory verbal learning trial I-V							
Kramer 2001	58	9.95 (1.8)	66	9.75 (2.1)		59.5 %	0.10 [-0.25, 0.45]
Subtotal (95% CI)	**58**		**66**			**59.5 %**	**0.10 [-0.25, 0.45]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.56 (P = 0.57)							
Total (95% CI)	**99**		**110**			**100.0 %**	**0.17 [-0.10, 0.44]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.74$, df = 3 (P = 0.86); I^2 =0.0%							
Test for overall effect: Z = 1.21 (P = 0.23)							



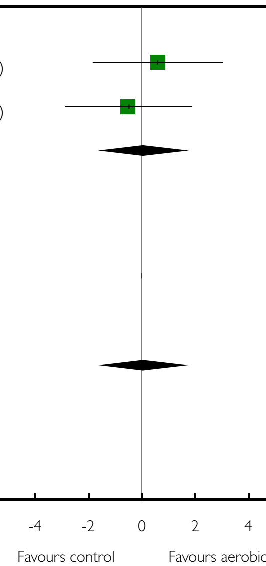
Analysis 1.3. Comparison 1 Aerobic exercise vs. any intervention, Outcome 3 Visual memory functions (immediate).

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 1 Aerobic exercise vs. any intervention

Outcome: 3 Visual memory functions (immediate)

Study or subgroup	Treatment N	Treatment Mean(SD)	Control N	Control Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
1 Benton visual retention (#error)							
Blumenthal 1989 a	15	-5.7 (3.5)	17	-6.3 (3.5)		49.2 %	0.60 [-1.83, 3.03]
Blumenthal 1989 b	16	-5.4 (3.2)	17	-4.9 (3.8)		50.8 %	-0.50 [-2.89, 1.89]
Subtotal (95% CI)	**31**		**34**			**100.0 %**	**0.04 [-1.66, 1.75]**
Heterogeneity: $Chi^2 = 0.40$, df = 1 (P = 0.53); I^2 =0.0%							
Test for overall effect: Z = 0.05 (P = 0.96)							
2 Wechsler Memory Scales visual reproduction							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
Total (95% CI)	**31**		**34**			**100.0 %**	**0.04 [-1.66, 1.75]**
Heterogeneity: $Chi^2 = 0.40$, df = 1 (P = 0.53); I^2 =0.0%							
Test for overall effect: Z = 0.05 (P = 0.96)							
Test for subgroup differences: Not applicable							



Analysis 1.4. Comparison 1 Aerobic exercise vs. any intervention, Outcome 4 Working memory.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

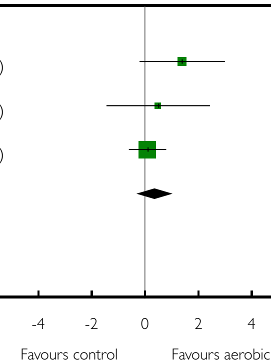
Comparison: 1 Aerobic exercise vs. any intervention

Outcome: 4 Working memory

Study or subgroup	Treatment N	Treatment Mean(SD)	Control N	Control Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
1 Digit span backward							
Blumenthal 1989 a	15	7.8 (2.8)	17	6.4 (1.6)		16.5 %	1.40 [-0.21, 3.01]
Blumenthal 1989 b	16	7.9 (2.9)	17	7.4 (2.8)		11.4 %	0.50 [-1.45, 2.45]
Kramer 2001	58	7.2 (1.83)	66	7.1 (2.11)		72.1 %	0.10 [-0.59, 0.79]
Total (95% CI)	**89**		**100**			**100.0 %**	**0.36 [-0.31, 1.03]**

Heterogeneity: $Tau^2 = 0.04$; $Chi^2 = 2.15$, df = 2 (P = 0.34); $I^2 = 7\%$

Test for overall effect: Z = 1.05 (P = 0.29)



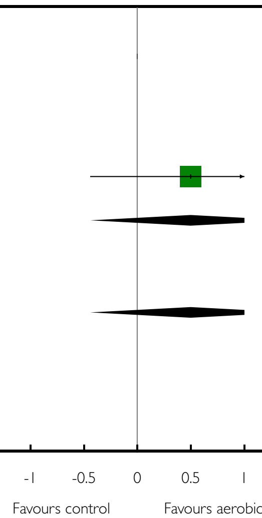
Analysis 1.5. Comparison 1 Aerobic exercise vs. any intervention, Outcome 5 Memory functions (delayed).

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 1 Aerobic exercise vs. any intervention

Outcome: 5 Memory functions (delayed)

Study or subgroup	Treatment N	Treatment Mean(SD)	Control N	Control Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
1 16 words delayed recall							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
2 Rey auditory verbal learning delayed recall trial							
Kramer 2001	58	11.4 (2.7)	66	10.9 (2.6)		100.0 %	0.50 [-0.44, 1.44]
Subtotal (95% CI)	**58**		**66**			**100.0 %**	**0.50 [-0.44, 1.44]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.05 (P = 0.30)							
Total (95% CI)	**58**		**66**			**100.0 %**	**0.50 [-0.44, 1.44]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.05 (P = 0.30)							
Test for subgroup differences: Not applicable							



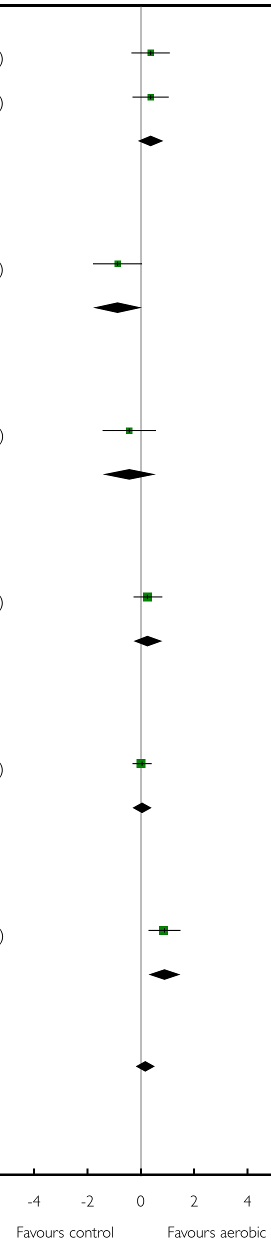
Analysis 1.6. Comparison 1 Aerobic exercise vs. any intervention, Outcome 6 Executive functions.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 1 Aerobic exercise vs. any intervention

Outcome: 6 Executive functions

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Trailmaking part B							
Blumenthal 1989 a	15	-83.1 (32)	17	-94.4 (30.1)		13.4 %	0.36 [-0.35, 1.06]
Blumenthal 1989 b	16	-76.1 (22.8)	17	-87.4 (37.5)		13.6 %	0.35 [-0.34, 1.04]
Subtotal (95% CI)	**31**		**34**			**27.0 %**	**0.35 [-0.14, 0.85]**
Heterogeneity: Tau^2 = 0.0; Chi^2 = 0.00, df = 1 (P = 1.00); I^2 =0.0%							
Test for overall effect: Z = 1.41 (P = 0.16)							
2 Ross Information Processing Assessment problem solving and abstract reasoning							
Moul 1995	10	27.3 (3.48)	10	29.6 (0.63)		9.6 %	-0.88 [-1.81, 0.05]
Subtotal (95% CI)	**10**		**10**			**9.6 %**	**-0.88 [-1.81, 0.05]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.86 (P = 0.063)							
3 Wechsler Memory Scales mental control							
Fabre 2002	8	5.9 (0.9)	8	6.3 (0.8)		8.7 %	-0.44 [-1.44, 0.55]
Subtotal (95% CI)	**8**		**8**			**8.7 %**	**-0.44 [-1.44, 0.55]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.87 (P = 0.38)							
4 Word comparison (#error)							
Madden 1989	25	-2.41 (2.76)	28	-3.18 (3.46)		17.0 %	0.24 [-0.30, 0.78]
Subtotal (95% CI)	**25**		**28**			**17.0 %**	**0.24 [-0.30, 0.78]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.87 (P = 0.38)							
5 Task switching paradigm (accuracy)							
Kramer 2001	58	95.8 (6.32)	66	95.6 (7.39)		22.1 %	0.03 [-0.32, 0.38]
Subtotal (95% CI)	**58**		**66**			**22.1 %**	**0.03 [-0.32, 0.38]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.16 (P = 0.87)							
6 Verbal fluency							
Emery 1998	25	33.9 (7.2)	23	27.6 (7)		15.7 %	0.87 [0.28, 1.47]
Subtotal (95% CI)	**25**		**23**			**15.7 %**	**0.87 [0.28, 1.47]**
Heterogeneity: not applicable							
Test for overall effect: Z = 2.87 (P = 0.0041)							
Total (95% CI)	**157**		**169**			**100.0 %**	**0.16 [-0.20, 0.51]**
Heterogeneity: Tau^2 = 0.11; Chi^2 = 12.96, df = 6 (P = 0.04); I^2 =54%							
Test for overall effect: Z = 0.87 (P = 0.38)							



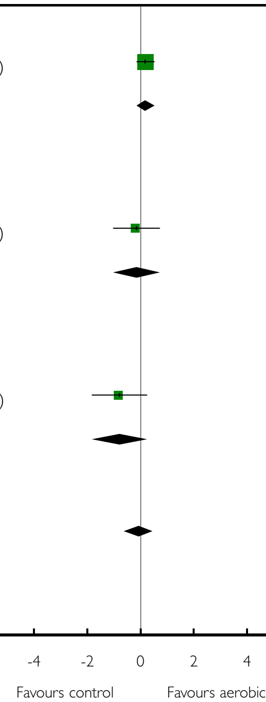
Analysis 1.7. Comparison 1 Aerobic exercise vs. any intervention, Outcome 7 Perception.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 1 Aerobic exercise vs. any intervention

Outcome: 7 Perception

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Face recognition (delayed recall)							
Kramer 2001	58	75.1 (18.28)	66	71.4 (23.56)		56.3 %	0.17 [-0.18, 0.53]
Subtotal (95% CI)	**58**		**66**			**56.3 %**	**0.17 [-0.18, 0.53]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.96 (P = 0.34)							
2 Ross Information Processing Assessment auditory processing							
Moul 1995	10	27.7 (3.8)	10	28.2 (0.95)		24.3 %	-0.17 [-1.05, 0.71]
Subtotal (95% CI)	**10**		**10**			**24.3 %**	**-0.17 [-1.05, 0.71]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.39 (P = 0.70)							
3 Wechsler Adult Intelligence Scales visual reproduction							
Fabre 2002	8	10.2 (2.8)	8	12 (1)		19.4 %	-0.81 [-1.84, 0.22]
Subtotal (95% CI)	**8**		**8**			**19.4 %**	**-0.81 [-1.84, 0.22]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.54 (P = 0.12)							
Total (95% CI)	**76**		**84**			**100.0 %**	**-0.10 [-0.63, 0.43]**
Heterogeneity: $Tau^2 = 0.10$; $Chi^2 = 3.37$, df = 2 (P = 0.19); I^2 =41%							
Test for overall effect: Z = 0.38 (P = 0.71)							



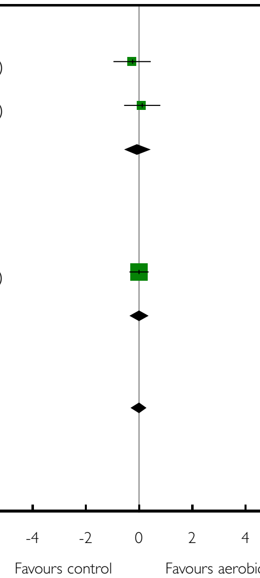
Analysis 1.8. Comparison 1 Aerobic exercise vs. any intervention, Outcome 8 Cognitive inhibition.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 1 Aerobic exercise vs. any intervention

Outcome: 8 Cognitive inhibition

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Stroop color word (interference)							
Blumenthal 1989 a	15	-2.6 (6.7)	17	-1 (5.4)		16.8 %	-0.26 [-0.96, 0.44]
Blumenthal 1989 b	16	-0.8 (5.9)	17	-1.5 (6.8)		17.5 %	0.11 [-0.58, 0.79]
Subtotal (95% CI)	**31**		**34**			**34.3 %**	**-0.07 [-0.56, 0.42]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.54$, df = 1 (P = 0.46); I^2 =0.0%							
Test for overall effect: Z = 0.29 (P = 0.77)							
2 Stopping task (accuracy choice RT)							
Kramer 2001	58	93.1 (132.51)	66	92.3 (150.3)		65.7 %	0.01 [-0.35, 0.36]
Subtotal (95% CI)	**58**		**66**			**65.7 %**	**0.01 [-0.35, 0.36]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.03 (P = 0.98)							
Total (95% CI)	**89**		**100**			**100.0 %**	**-0.02 [-0.31, 0.26]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.60$, df = 2 (P = 0.74); I^2 =0.0%							
Test for overall effect: Z = 0.14 (P = 0.89)							



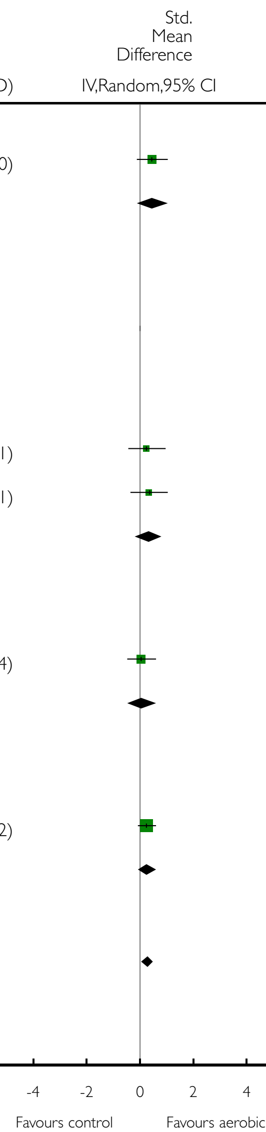
Analysis 1.9. Comparison 1 Aerobic exercise vs. any intervention, Outcome 9 Visual attention.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 1 Aerobic exercise vs. any intervention

Outcome: 9 Visual attention

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Weight	Std. Mean Difference IV,Random,95% CI
1 Digit vigilance						
Emery 1998	25	-198.6 (45.9)	23	-220.3 (50)	16.3 %	0.45 [-0.13, 1.02]
Subtotal (95% CI)	**25**		**23**		**16.3 %**	**0.45 [-0.13, 1.02]**
Heterogeneity: not applicable						
Test for overall effect: Z = 1.52 (P = 0.13)						
2 Tracking (accuracy index)						
Subtotal (95% CI)	**0**		**0**			**Not estimable**
Heterogeneity: not applicable						
Test for overall effect: not applicable						
3 2%7 test						
Blumenthal 1989 a	15	-6.3 (4.35)	17	-7.85 (7.1)	11.0 %	0.25 [-0.44, 0.95]
Blumenthal 1989 b	16	-7.25 (5.65)	17	-10.35 (11)	11.3 %	0.34 [-0.35, 1.03]
Subtotal (95% CI)	**31**		**34**		**22.4 %**	**0.30 [-0.19, 0.79]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.03$, df = 1 (P = 0.86); I^2 =0.0%						
Test for overall effect: Z = 1.19 (P = 0.23)						
4 Letter search primary task RT						
Madden 1989	25	-1012.33 (211.26)	28	-1023.67 (248.14)	18.5 %	0.05 [-0.49, 0.59]
Subtotal (95% CI)	**25**		**28**		**18.5 %**	**0.05 [-0.49, 0.59]**
Heterogeneity: not applicable						
Test for overall effect: Z = 0.18 (P = 0.86)						
5 Visual search (accuracy)						
Kramer 2001	58	97.75 (3.34)	66	96.95 (3.02)	42.8 %	0.25 [-0.10, 0.60]
Subtotal (95% CI)	**58**		**66**		**42.8 %**	**0.25 [-0.10, 0.60]**
Heterogeneity: not applicable						
Test for overall effect: Z = 1.39 (P = 0.17)						
Total (95% CI)	**139**		**151**		**100.0 %**	**0.26 [0.02, 0.49]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 1.05$, df = 4 (P = 0.90); I^2 =0.0%						
Test for overall effect: Z = 2.16 (P = 0.031)						



Analysis 1.10. Comparison 1 Aerobic exercise vs. any intervention, Outcome 10 Auditory attention.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

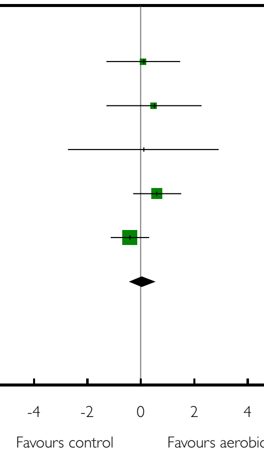
Comparison: 1 Aerobic exercise vs. any intervention

Outcome: 10 Auditory attention

Study or subgroup	Treatment N	Treatment Mean(SD)	Control N	Control Mean(SD)	Weight	Mean Difference IV,Random,95% CI
1 Digit span forward						
Blumenthal 1989 a	15	8 (2.3)	17	7.9 (1.6)	12.6 %	0.10 [-1.29, 1.49]
Blumenthal 1989 b	16	9.8 (2.8)	17	9.3 (2.4)	7.6 %	0.50 [-1.28, 2.28]
Emery 1990 a	14	11.5 (4.3)	24	11.4 (4.2)	3.1 %	0.10 [-2.71, 2.91]
Fabre 2002	8	6.1 (0.7)	8	5.5 (1.1)	29.8 %	0.60 [-0.30, 1.50]
Kramer 2001	58	8 (1.98)	66	8.4 (2.11)	46.9 %	-0.40 [-1.12, 0.32]
Total (95% CI)	**111**		**132**		**100.0 %**	**0.05 [-0.45, 0.54]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 3.17$, df = 4 (P = 0.53); $I^2 = 0.0\%$

Test for overall effect: Z = 0.18 (P = 0.86)



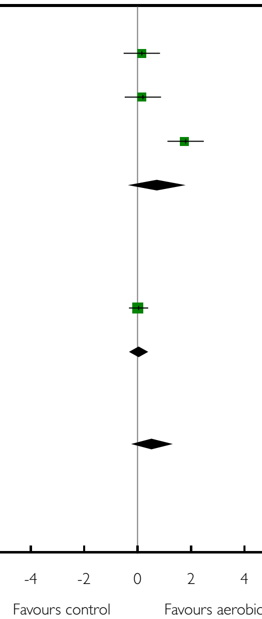
Analysis 1.11. Comparison 1 Aerobic exercise vs. any intervention, Outcome 11 Motor function.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 1 Aerobic exercise vs. any intervention

Outcome: 11 Motor function

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Finger tapping							
Blumenthal 1989 a	15	115.1 (14.4)	17	112.5 (17.8)		23.9 %	0.16 [-0.54, 0.85]
Blumenthal 1989 b	16	131.6 (14.3)	17	128.2 (19.7)		24.1 %	0.19 [-0.49, 0.88]
Emery 1998	25	43.3 (2.1)	23	39.8 (1.7)		24.1 %	1.79 [1.11, 2.47]
Subtotal (95% CI)	**56**		**57**			**72.1 %**	**0.72 [-0.35, 1.78]**
Heterogeneity: $Tau^2 = 0.76$; $Chi^2 = 14.43$, df = 2 (P = 0.00074); I^2 =86%							
Test for overall effect: Z = 1.32 (P = 0.19)							
2 Pursuit rotor task (tracking error)							
Kramer 2001	58	-29.65 (6.25)	66	-29.8 (6.56)		27.9 %	0.02 [-0.33, 0.38]
Subtotal (95% CI)	**58**		**66**			**27.9 %**	**0.02 [-0.33, 0.38]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.13 (P = 0.90)							
Total (95% CI)	**114**		**123**			**100.0 %**	**0.52 [-0.25, 1.30]**
Heterogeneity: $Tau^2 = 0.53$; $Chi^2 = 21.16$, df = 3 (P = 0.00010); I^2 =86%							
Test for overall effect: Z = 1.32 (P = 0.19)							



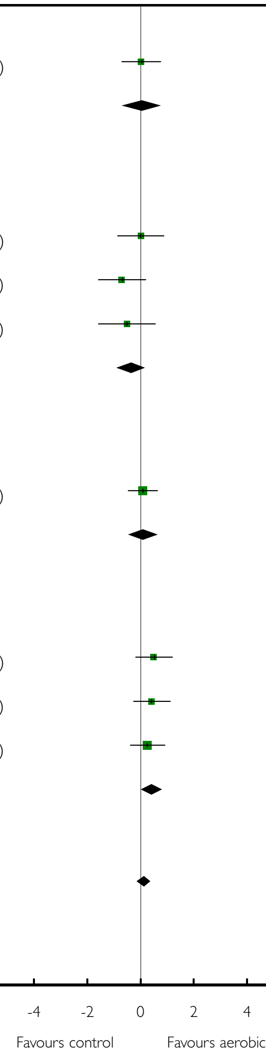
Analysis 2.1. Comparison 2 Aerobic exercise vs. no intervention, Outcome 1 Cognitive speed.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 2 Aerobic exercise vs. no intervention

Outcome: 1 Cognitive speed

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Simple reaction time							
Panton 1990	17	-274 (28.9)	12	-275 (52)		12.3 %	0.02 [-0.71, 0.76]
Subtotal (95% CI)	**17**		**12**			**12.3 %**	**0.02 [-0.71, 0.76]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.06 (P = 0.95)							
2 Choice reaction time							
Hassm n 1997 a	10	-790 (136)	10	-792 (196)		8.8 %	0.01 [-0.87, 0.89]
Hassm n 1997 b	10	-819 (142.3)	10	-681 (224.5)		8.1 %	-0.70 [-1.61, 0.21]
Whitehurst 1991	7	-0.41 (0.03)	7	-0.39 (0.04)		5.9 %	-0.53 [-1.60, 0.54]
Subtotal (95% CI)	**27**		**27**			**22.8 %**	**-0.38 [-0.93, 0.16]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 1.33$, df = 2 (P = 0.52); $I^2 = 0.0\%$							
Test for overall effect: Z = 1.38 (P = 0.17)							
3 Trailmaking part A							
Emery 1998	25	-33.5 (9.7)	25	-34.5 (13.5)		21.9 %	0.08 [-0.47, 0.64]
Subtotal (95% CI)	**25**		**25**			**21.9 %**	**0.08 [-0.47, 0.64]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.30 (P = 0.77)							
4 Digit symbol substitution							
Blumenthal 1989 a	15	54.6 (8.6)	18	49.9 (9.5)		13.9 %	0.50 [-0.19, 1.20]
Blumenthal 1989 b	16	50.5 (9.3)	16	46.2 (10.9)		13.7 %	0.41 [-0.29, 1.12]
Emery 1990 a	14	35.8 (12.6)	24	32.9 (11.3)		15.4 %	0.24 [-0.42, 0.90]
Subtotal (95% CI)	**45**		**58**			**43.0 %**	**0.38 [-0.02, 0.78]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.30$, df = 2 (P = 0.86); $I^2 = 0.0\%$							
Test for overall effect: Z = 1.88 (P = 0.060)							
Total (95% CI)	**114**		**122**			**100.0 %**	**0.10 [-0.16, 0.36]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 6.63$, df = 7 (P = 0.47); $I^2 = 0.0\%$							
Test for overall effect: Z = 0.74 (P = 0.46)							



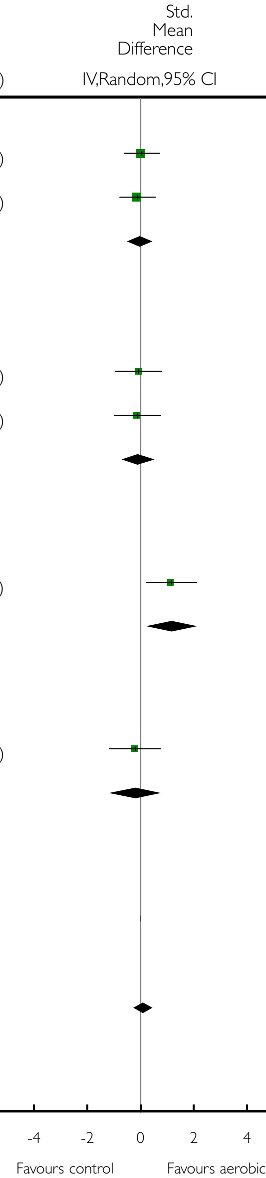
Analysis 2.2. Comparison 2 Aerobic exercise vs. no intervention, Outcome 2 Verbal memory functions (immediate).

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 2 Aerobic exercise vs. no intervention

Outcome: 2 Verbal memory functions (immediate)

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Weight	Std. Mean Difference IV,Random,95% CI
1 Randt Memory test story recall						
Blumenthal 1989 a	15	10.7 (3.6)	18	10.6 (4.2)	22.8 %	0.02 [-0.66, 0.71]
Blumenthal 1989 b	16	11.4 (4.1)	16	11.9 (3.4)	22.4 %	-0.13 [-0.82, 0.56]
Subtotal (95% CI)	**31**		**34**		**45.2 %**	**-0.05 [-0.54, 0.44]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.10$, df = 1 (P = 0.76); I^2 =0.0%						
Test for overall effect: Z = 0.21 (P = 0.84)						
2 16 words immediate recall						
Hassm n 1997 a	10	8.2 (2.2)	10	8.4 (2.5)	15.0 %	-0.08 [-0.96, 0.80]
Hassm n 1997 b	10	9.4 (2.2)	10	9.7 (1.9)	14.9 %	-0.14 [-1.02, 0.74]
Subtotal (95% CI)	**20**		**20**		**29.9 %**	**-0.11 [-0.73, 0.51]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.01$, df = 1 (P = 0.93); I^2 =0.0%						
Test for overall effect: Z = 0.35 (P = 0.73)						
3 Ross Information Processing Assessment immediate memory						
Moul 1995	10	23.5 (3.48)	10	16 (8.22)	12.7 %	1.14 [0.18, 2.10]
Subtotal (95% CI)	**10**		**10**		**12.7 %**	**1.14 [0.18, 2.10]**
Heterogeneity: not applicable						
Test for overall effect: Z = 2.32 (P = 0.020)						
4 Wechsler Adult Intelligence Scales logical memory immediate recall						
Fabre 2002	8	7.4 (1)	8	7.7 (1.5)	12.2 %	-0.22 [-1.21, 0.76]
Subtotal (95% CI)	**8**		**8**		**12.2 %**	**-0.22 [-1.21, 0.76]**
Heterogeneity: not applicable						
Test for overall effect: Z = 0.44 (P = 0.66)						
5 Rey auditory verbal learning trial I-V						
Subtotal (95% CI)	**0**		**0**			**Not estimable**
Heterogeneity: not applicable						
Test for overall effect: not applicable						
Total (95% CI)	**69**		**72**		**100.0 %**	**0.06 [-0.30, 0.42]**
Heterogeneity: $Tau^2 = 0.03$; $Chi^2 = 5.75$, df = 5 (P = 0.33); I^2 =13%						
Test for overall effect: Z = 0.33 (P = 0.74)						



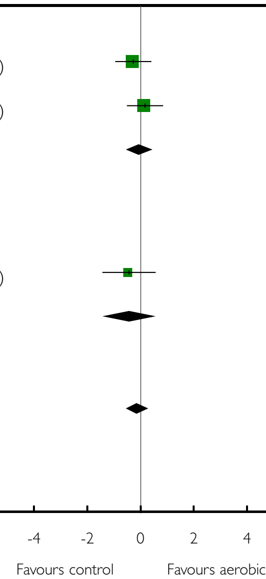
Analysis 2.3. Comparison 2 Aerobic exercise vs. no intervention, Outcome 3 Visual memory functions (immediate).

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 2 Aerobic exercise vs. no intervention

Outcome: 3 Visual memory functions (immediate)

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Weight	Std. Mean Difference IV,Random,95% CI
1 Benton visual retention (#error)						
Blumenthal 1989 a	15	-5.7 (3.5)	18	-4.7 (3.2)	40.6 %	-0.29 [-0.98, 0.40]
Blumenthal 1989 b	16	-5.4 (3.2)	16	-5.9 (3.1)	40.0 %	0.15 [-0.54, 0.85]
Subtotal (95% CI)	**31**		**34**		**80.6 %**	**-0.07 [-0.56, 0.42]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.80$, df = 1 (P = 0.37); $I^2 = 0.0\%$						
Test for overall effect: Z = 0.28 (P = 0.78)						
2 Wechsler Memory Scales visual reproduction						
Fabre 2002	8	10.2 (2.8)	8	11.3 (1.6)	19.4 %	-0.46 [-1.45, 0.54]
Subtotal (95% CI)	**8**		**8**		**19.4 %**	**-0.46 [-1.45, 0.54]**
Heterogeneity: not applicable						
Test for overall effect: Z = 0.90 (P = 0.37)						
Total (95% CI)	**39**		**42**		**100.0 %**	**-0.15 [-0.58, 0.29]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 1.27$, df = 2 (P = 0.53); $I^2 = 0.0\%$						
Test for overall effect: Z = 0.65 (P = 0.52)						



Analysis 2.4. Comparison 2 Aerobic exercise vs. no intervention, Outcome 4 Working memory.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 2 Aerobic exercise vs. no intervention

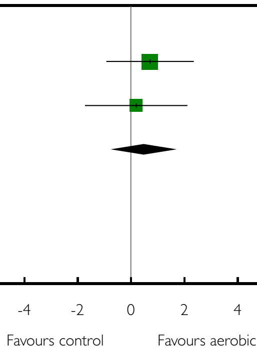
Outcome: 4 Working memory

Study or subgroup	Treatment N	Treatment Mean(SD)	Control N	Control Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
1 Digit span backward							
Blumenthal 1989 a	15	7.8 (2.8)	18	7.1 (1.8)		57.4 %	0.70 [-0.94, 2.34]
Blumenthal 1989 b	16	7.8 (2.9)	16	7.6 (2.6)		42.6 %	0.20 [-1.71, 2.11]
Total (95% CI)	**31**		**34**			**100.0 %**	**0.49 [-0.76, 1.73]**

Heterogeneity: $Chi^2 = 0.15$, df = 1 (P = 0.70); I^2 =0.0%

Test for overall effect: Z = 0.77 (P = 0.44)

Test for subgroup differences: Not applicable



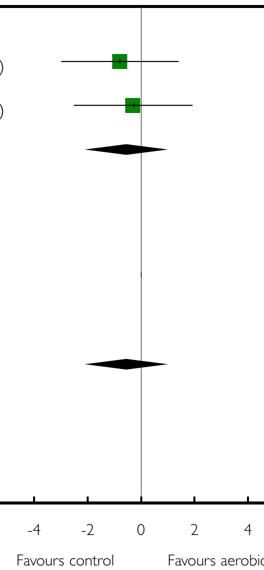
Analysis 2.5. Comparison 2 Aerobic exercise vs. no intervention, Outcome 5 Memory functions (delayed).

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 2 Aerobic exercise vs. no intervention

Outcome: 5 Memory functions (delayed)

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
1 16 words delayed recall							
Hassm n 1997 a	10	6.1 (2.5)	10	6.9 (2.5)		50.4 %	-0.80 [-2.99, 1.39]
Hassm n 1997 b	10	6.9 (2.2)	10	7.2 (2.8)		49.6 %	-0.30 [-2.51, 1.91]
Subtotal (95% CI)	**20**		**20**			**100.0 %**	**-0.55 [-2.11, 1.00]**
Heterogeneity: Chi^2 = 0.10, df = 1 (P = 0.75); I^2 =0.0%							
Test for overall effect: Z = 0.70 (P = 0.49)							
2 Rey auditory verbal learning delayed recall trial							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
Total (95% CI)	**20**		**20**			**100.0 %**	**-0.55 [-2.11, 1.00]**
Heterogeneity: Chi^2 = 0.10, df = 1 (P = 0.75); I^2 =0.0%							
Test for overall effect: Z = 0.70 (P = 0.49)							
Test for subgroup differences: Not applicable							



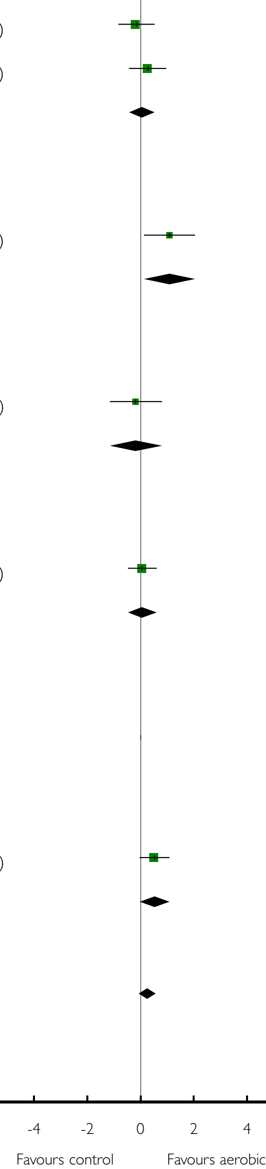
Analysis 2.6. Comparison 2 Aerobic exercise vs. no intervention, Outcome 6 Executive functions.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 2 Aerobic exercise vs. no intervention

Outcome: 6 Executive functions

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Trailmaking part B							
Blumenthal 1989 a	15	-83.1 (32)	18	-77.9 (27.7)		17.1 %	-0.17 [-0.86, 0.52]
Blumenthal 1989 b	16	-76.1 (22.8)	16	-85.5 (44.1)		16.8 %	0.26 [-0.44, 0.96]
Subtotal (95% CI)	**31**		**34**			**33.9 %**	**0.04 [-0.45, 0.53]**
Heterogeneity: Tau^2 = 0.0; Chi^2 = 0.75, df = 1 (P = 0.39); I^2 =0.0%							
Test for overall effect: Z = 0.17 (P = 0.87)							
2 Ross Information Processing Assessment problem solving and abstract reasoning							
Moul 1995	10	27.3 (3.48)	10	23 (4.11)		10.0 %	1.08 [0.13, 2.03]
Subtotal (95% CI)	**10**		**10**			**10.0 %**	**1.08 [0.13, 2.03]**
Heterogeneity: not applicable							
Test for overall effect: Z = 2.22 (P = 0.026)							
3 Wechsler Memory Scales mental control							
Fabre 2002	8	5.9 (0.9)	8	6.1 (1.1)		9.4 %	-0.19 [-1.17, 0.79]
Subtotal (95% CI)	**8**		**8**			**9.4 %**	**-0.19 [-1.17, 0.79]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.38 (P = 0.71)							
4 Word comparison (#error)							
Madden 1989	25	-2.41 (2.76)	26	-2.56 (2.89)		23.8 %	0.05 [-0.50, 0.60]
Subtotal (95% CI)	**25**		**26**			**23.8 %**	**0.05 [-0.50, 0.60]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.19 (P = 0.85)							
5 Task switching paradigm (accuracy)							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
6 Verbal fluency							
Emery 1998	25	33.9 (7.2)	25	29.8 (8.7)		22.9 %	0.51 [-0.06, 1.07]
Subtotal (95% CI)	**25**		**25**			**22.9 %**	**0.51 [-0.06, 1.07]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.76 (P = 0.079)							
Total (95% CI)	**99**		**103**			**100.0 %**	**0.23 [-0.09, 0.56]**
Heterogeneity: Tau^2 = 0.04; Chi^2 = 6.40, df = 5 (P = 0.27); I^2 =22%							
Test for overall effect: Z = 1.41 (P = 0.16)							



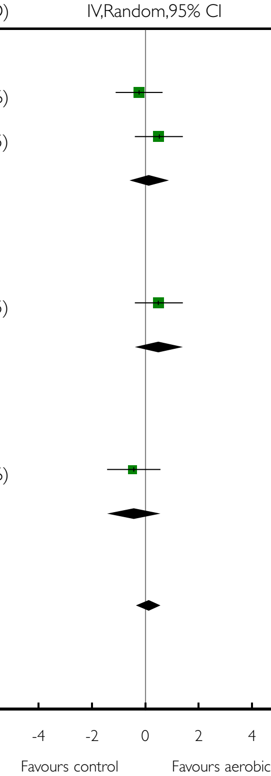
Analysis 2.7. Comparison 2 Aerobic exercise vs. no intervention, Outcome 7 Perception.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 2 Aerobic exercise vs. no intervention

Outcome: 7 Perception

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Face recognition (delayed recall)							
Hassm n 1997 a	10	2.1 (0.95)	10	2.3 (0.6)		26.7 %	-0.24 [-1.12, 0.64]
Hassm n 1997 b	10	2.6 (1.3)	10	2 (0.95)		26.0 %	0.50 [-0.39, 1.40]
Subtotal (95% CI)	**20**		**20**			**52.7 %**	**0.13 [-0.60, 0.86]**
Heterogeneity: Tau^2 = 0.07; Chi^2 = 1.36, df = 1 (P = 0.24); I^2 =26%							
Test for overall effect: Z = 0.34 (P = 0.73)							
2 Ross Information Processing Assessment auditory processing							
Moul 1995	10	27.7 (3.8)	10	26 (2.85)		26.1 %	0.48 [-0.41, 1.38]
Subtotal (95% CI)	**10**		**10**			**26.1 %**	**0.48 [-0.41, 1.38]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.06 (P = 0.29)							
3 Wechsler Adult Intelligence Scales visual reproduction							
Fabre 2002	8	10.2 (2.8)	8	11.3 (1.6)		21.3 %	-0.46 [-1.45, 0.54]
Subtotal (95% CI)	**8**		**8**			**21.3 %**	**-0.46 [-1.45, 0.54]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.90 (P = 0.37)							
Total (95% CI)	**38**		**38**			**100.0 %**	**0.10 [-0.38, 0.57]**
Heterogeneity: Tau^2 = 0.02; Chi^2 = 3.27, df = 3 (P = 0.35); I^2 =8%							
Test for overall effect: Z = 0.40 (P = 0.69)							



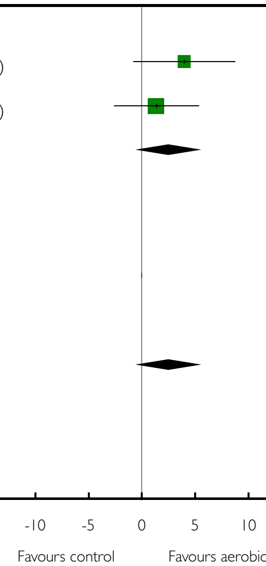
Analysis 2.8. Comparison 2 Aerobic exercise vs. no intervention, Outcome 8 Cognitive inhibition.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 2 Aerobic exercise vs. no intervention

Outcome: 8 Cognitive inhibition

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
1 Stroop color word (interference)							
Blumenthal 1989 a	15	-2.6 (6.7)	18	-6.6 (7.4)		41.1 %	4.00 [-0.81, 8.81]
Blumenthal 1989 b	16	-0.8 (5.9)	16	-2.2 (5.7)		58.9 %	1.40 [-2.62, 5.42]
Subtotal (95% CI)	**31**		**34**			**100.0 %**	**2.47 [-0.62, 5.55]**
Heterogeneity: $Chi^2 = 0.66$, df = 1 (P = 0.42); I^2 =0.0%							
Test for overall effect: Z = 1.57 (P = 0.12)							
2 Stopping task (accuracy choice RT)							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
Total (95% CI)	**31**		**34**			**100.0 %**	**2.47 [-0.62, 5.55]**
Heterogeneity: $Chi^2 = 0.66$, df = 1 (P = 0.42); I^2 =0.0%							
Test for overall effect: Z = 1.57 (P = 0.12)							
Test for subgroup differences: Not applicable							



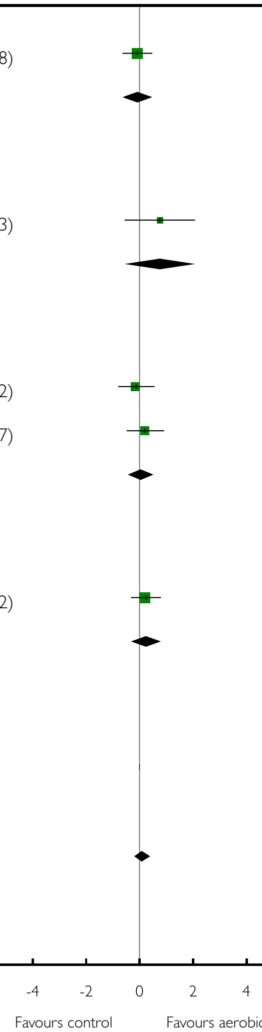
Analysis 2.9. Comparison 2 Aerobic exercise vs. no intervention, Outcome 9 Visual attention.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 2 Aerobic exercise vs. no intervention

Outcome: 9 Visual attention

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Digit vigilance							
Emery 1998	25	-198.6 (45.9)	25	-195 (38.8)		28.7 %	-0.08 [-0.64, 0.47]
Subtotal (95% CI)	**25**		**25**			**28.7 %**	**-0.08 [-0.64, 0.47]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.29 (P = 0.77)							
2 Tracking (accuracy index)							
Bakken 2001	5	10.1 (23.4)	5	-16.2 (37.3)		5.1 %	0.76 [-0.55, 2.07]
Subtotal (95% CI)	**5**		**5**			**5.1 %**	**0.76 [-0.55, 2.07]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.14 (P = 0.25)							
3 2%7 test							
Blumenthal 1989 a	15	6.3 (4.35)	18	6.95 (5.2)		18.8 %	-0.13 [-0.82, 0.55]
Blumenthal 1989 b	16	7.25 (5.65)	16	6.15 (4.7)		18.3 %	0.21 [-0.49, 0.90]
Subtotal (95% CI)	**31**		**34**			**37.1 %**	**0.04 [-0.45, 0.52]**
Heterogeneity: Tau^2 = 0.0; Chi^2 = 0.46, df = 1 (P = 0.50); I^2 =0.0%							
Test for overall effect: Z = 0.14 (P = 0.89)							
4 Letter search primary task RT							
Madden 1989	25	-1012.33 (211.26)	26	-1055.83 (163.72)		29.1 %	0.23 [-0.32, 0.78]
Subtotal (95% CI)	**25**		**26**			**29.1 %**	**0.23 [-0.32, 0.78]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.81 (P = 0.42)							
5 Visual search (accuracy)							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
Total (95% CI)	**86**		**90**			**100.0 %**	**0.09 [-0.20, 0.39]**
Heterogeneity: Tau^2 = 0.0; Chi^2 = 2.13, df = 4 (P = 0.71); I^2 =0.0%							
Test for overall effect: Z = 0.62 (P = 0.53)							



Analysis 2.10. Comparison 2 Aerobic exercise vs. no intervention, Outcome 10 Auditory attention.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

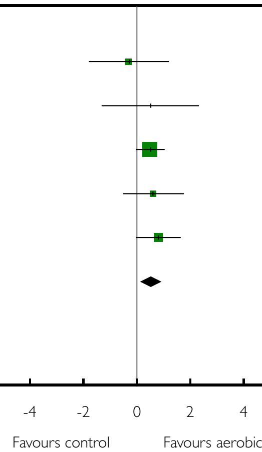
Comparison: 2 Aerobic exercise vs. no intervention

Outcome: 10 Auditory attention

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
1 Digit span forward							
Blumenthal 1989 a	15	8 (2.3)	18	8.3 (2)		6.9 %	-0.30 [-1.79, 1.19]
Blumenthal 1989 b	16	9.8 (2.8)	16	9.3 (2.4)		4.7 %	0.50 [-1.31, 2.31]
Fabre 2002	8	6.1 (0.7)	8	5.6 (0.3)		54.7 %	0.50 [-0.03, 1.03]
Hassm n 1997 a	10	8 (1.3)	10	7.4 (1.3)		11.7 %	0.60 [-0.54, 1.74]
Hassm n 1997 b	10	7.6 (0.95)	10	6.8 (0.95)		22.0 %	0.80 [-0.03, 1.63]
Total (95% CI)	**59**		**62**			**100.0 %**	**0.52 [0.13, 0.91]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 1.63$, df = 4 (P = 0.80); $I^2 = 0.0\%$

Test for overall effect: Z = 2.62 (P = 0.0087)



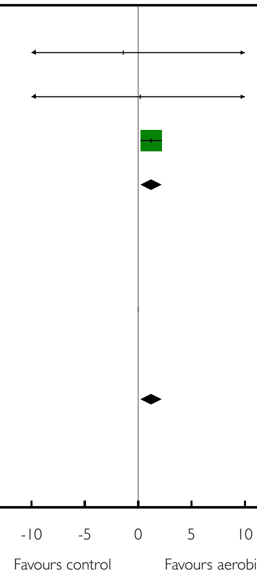
Analysis 2.11. Comparison 2 Aerobic exercise vs. no intervention, Outcome 11 Motor function.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 2 Aerobic exercise vs. no intervention

Outcome: 11 Motor function

Study or subgroup	Treatment N	Treatment Mean(SD)	Control N	Control Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
1 Finger tapping							
Blumenthal 1989 a	15	115.1 (14.4)	18	116.5 (19.1)		0.7 %	-1.40 [-12.84, 10.04]
Blumenthal 1989 b	16	131.6 (14.3)	16	131.4 (17.5)		0.8 %	0.20 [-10.87, 11.27]
Emery 1998	25	43.3 (2.1)	25	42.1 (1.4)		98.5 %	1.20 [0.21, 2.19]
Subtotal (95% CI)	**56**		**59**			**100.0 %**	**1.17 [0.19, 2.15]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.23$, df = 2 (P = 0.89); I^2 =0.0%							
Test for overall effect: Z = 2.34 (P = 0.019)							
2 Pursuit rotor task (tracking error)							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
Total (95% CI)	**56**		**59**			**100.0 %**	**1.17 [0.19, 2.15]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.23$, df = 2 (P = 0.89); I^2 =0.0%							
Test for overall effect: Z = 2.34 (P = 0.019)							



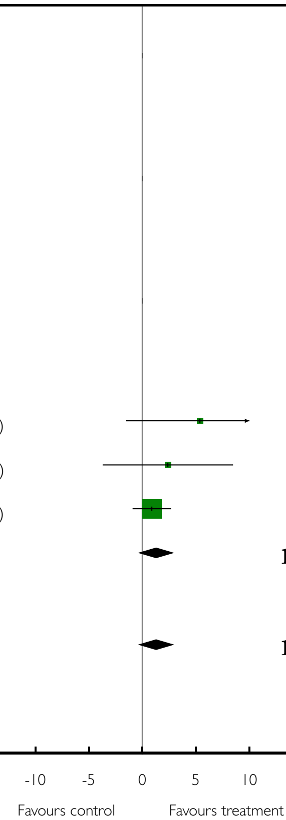
Analysis 3.1. Comparison 3 Aerobic exercise vs. flexibility / balance programme, Outcome 1 Cognitive speed.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 3 Aerobic exercise vs. flexibility / balance programme

Outcome: 1 Cognitive speed

Study or subgroup	Treatment N	Treatment Mean(SD)	Control N	Control Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
1 Simple reaction time							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
2 Choice reaction time							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
3 Trailmaking part A							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
4 Digit symbol substitution							
Blumenthal 1989 a	15	54.6 (8.6)	17	49.2 (11.3)		6.0 %	5.40 [-1.51, 12.31]
Blumenthal 1989 b	16	50.5 (9.3)	17	48.1 (8.5)		7.8 %	2.40 [-3.69, 8.49]
Kramer 2001	58	96.6 (3.88)	66	95.7 (6.34)		86.2 %	0.90 [-0.93, 2.73]
Subtotal (95% CI)	**89**		**100**			**100.0 %**	**1.29 [-0.41, 2.98]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 1.66$, df = 2 (P = 0.44); $I^2 = 0.0\%$							
Test for overall effect: Z = 1.49 (P = 0.14)							
Total (95% CI)	**89**		**100**			**100.0 %**	**1.29 [-0.41, 2.98]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 1.66$, df = 2 (P = 0.44); $I^2 = 0.0\%$							
Test for overall effect: Z = 1.49 (P = 0.14)							



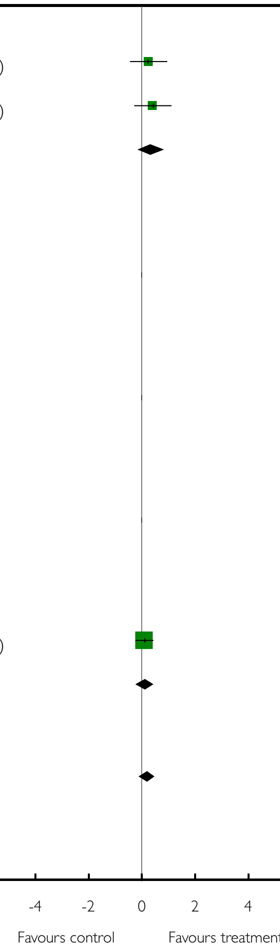
Analysis 3.2. Comparison 3 Aerobic exercise vs. flexibility / balance programme, Outcome 2 Verbal memory functions (immediate).

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 3 Aerobic exercise vs. flexibility / balance programme

Outcome: 2 Verbal memory functions (immediate)

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Randt Memory test story recall							
Blumenthal 1989 a	15	10.7 (3.6)	17	9.8 (3.5)		16.9 %	0.25 [-0.45, 0.94]
Blumenthal 1989 b	16	11.4 (4.1)	17	9.8 (3.4)		17.2 %	0.42 [-0.28, 1.11]
Subtotal (95% CI)	**31**		**34**			**34.1 %**	**0.33 [-0.16, 0.82]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.11$, df = 1 (P = 0.74); $I^2 = 0.0\%$							
Test for overall effect: Z = 1.33 (P = 0.18)							
2 16 words immediate recall							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
3 Ross Information Processing Assessment immediate memory							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
4 Wechsler Adult Intelligence Scales logical memory immediate recall							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
5 Rey auditory verbal learning trial I-V							
Kramer 2001	58	9.95 (1.8)	66	9.75 (2.1)		65.9 %	0.10 [-0.25, 0.45]
Subtotal (95% CI)	**58**		**66**			**65.9 %**	**0.10 [-0.25, 0.45]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.56 (P = 0.57)							
Total (95% CI)	**89**		**100**			**100.0 %**	**0.18 [-0.11, 0.47]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.67$, df = 2 (P = 0.71); $I^2 = 0.0\%$							
Test for overall effect: Z = 1.23 (P = 0.22)							



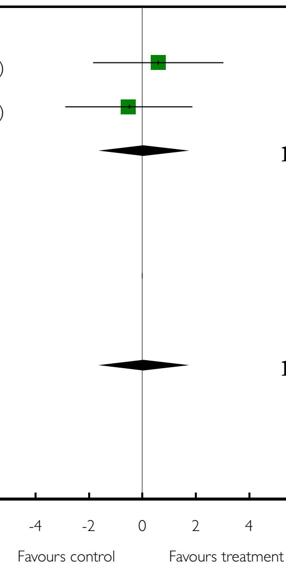
Analysis 3.3. Comparison 3 Aerobic exercise vs. flexibility / balance programme, Outcome 3 Visual memory functions (immediate).

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 3 Aerobic exercise vs. flexibility / balance programme

Outcome: 3 Visual memory functions (immediate)

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
1 Benton visual retention (#error)							
Blumenthal 1989 a	15	-5.7 (3.5)	17	-6.3 (3.5)		49.2 %	0.60 [-1.83, 3.03]
Blumenthal 1989 b	16	-5.4 (3.2)	17	-4.9 (3.8)		50.8 %	-0.50 [-2.89, 1.89]
Subtotal (95% CI)	**31**		**34**			**100.0 %**	**0.04 [-1.66, 1.75]**
Heterogeneity: $Chi^2 = 0.40$, df = 1 (P = 0.53); $I^2 = 0.0\%$							
Test for overall effect: Z = 0.05 (P = 0.96)							
2 Wechsler Memory Scales visual reproduction							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
Total (95% CI)	**31**		**34**			**100.0 %**	**0.04 [-1.66, 1.75]**
Heterogeneity: $Chi^2 = 0.40$, df = 1 (P = 0.53); $I^2 = 0.0\%$							
Test for overall effect: Z = 0.05 (P = 0.96)							
Test for subgroup differences: Not applicable							



Analysis 3.4. Comparison 3 Aerobic exercise vs. flexibility / balance programme, Outcome 4 Working memory.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

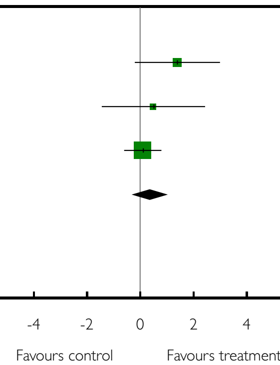
Comparison: 3 Aerobic exercise vs. flexibility / balance programme

Outcome: 4 Working memory

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
1 Digit span backward							
Blumenthal 1989 a	15	7.8 (2.8)	17	6.4 (1.6)		16.5 %	1.40 [-0.21, 3.01]
Blumenthal 1989 b	16	7.9 (2.9)	17	7.4 (2.8)		11.4 %	0.50 [-1.45, 2.45]
Kramer 2001	58	7.2 (1.83)	66	7.1 (2.11)		72.1 %	0.10 [-0.59, 0.79]
Total (95% CI)	**89**		**100**			**100.0 %**	**0.36 [-0.31, 1.03]**

Heterogeneity: $Tau^2 = 0.04$; $Chi^2 = 2.15$, df = 2 (P = 0.34); $I^2 = 7\%$

Test for overall effect: Z = 1.05 (P = 0.29)



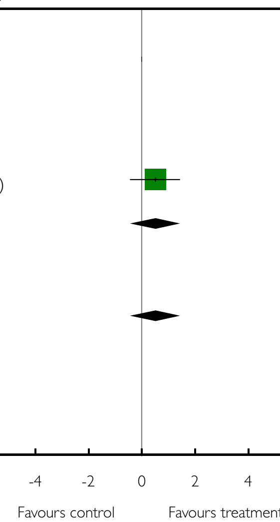
Analysis 3.5. Comparison 3 Aerobic exercise vs. flexibility / balance programme, Outcome 5 Memory functions (delayed).

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 3 Aerobic exercise vs. flexibility / balance programme

Outcome: 5 Memory functions (delayed)

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
1 16 words delayed recall							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
2 Rey auditory verbal learning delayed recall trial							
Kramer 2001	58	11.4 (2.7)	66	10.9 (2.6)		100.0 %	0.50 [-0.44, 1.44]
Subtotal (95% CI)	**58**		**66**			**100.0 %**	**0.50 [-0.44, 1.44]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.05 (P = 0.30)							
Total (95% CI)	**58**		**66**			**100.0 %**	**0.50 [-0.44, 1.44]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.05 (P = 0.30)							
Test for subgroup differences: Not applicable							



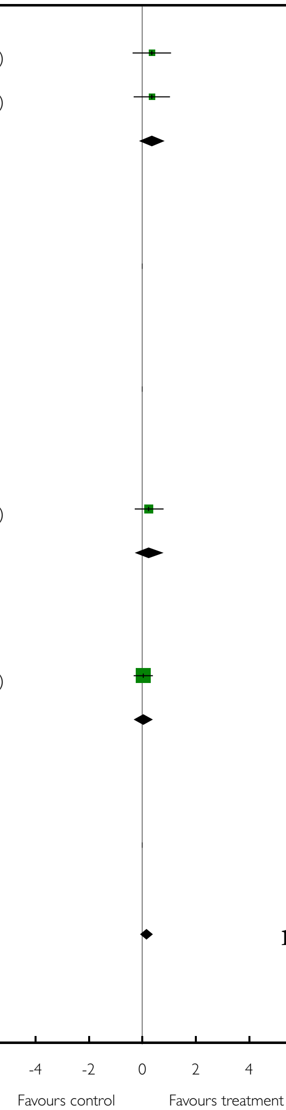
Analysis 3.6. Comparison 3 Aerobic exercise vs. flexibility / balance programme, Outcome 6 Executive functions.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 3 Aerobic exercise vs. flexibility / balance programme

Outcome: 6 Executive functions

Study or subgroup	Treatment N	Treatment Mean(SD)	Control N	Control Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Trailmaking part B							
Blumenthal 1989 a	15	-83.1 (32)	17	-94.4 (30.1)		13.1 %	0.36 [-0.35, 1.06]
Blumenthal 1989 b	16	-76.1 (22.8)	17	-87.4 (37.5)		13.5 %	0.35 [-0.34, 1.04]
Subtotal (95% CI)	**31**		**34**			**26.6 %**	**0.35 [-0.14, 0.85]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.00$, df = 1 (P = 1.00); $I^2 = 0.0\%$							
Test for overall effect: Z = 1.41 (P = 0.16)							
2 Ross Information Processing Assessment problem solving and abstract reasoning							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
3 Wechsler Memory Scales mental control							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
4 Word comparison (#error)							
Madden 1989	25	-2.41 (2.76)	28	-3.18 (3.46)		21.9 %	0.24 [-0.30, 0.78]
Subtotal (95% CI)	**25**		**28**			**21.9 %**	**0.24 [-0.30, 0.78]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.87 (P = 0.38)							
5 Task switching paradigm (accuracy)							
Kramer 2001	58	95.8 (6.32)	66	95.6 (7.39)		51.5 %	0.03 [-0.32, 0.38]
Subtotal (95% CI)	**58**		**66**			**51.5 %**	**0.03 [-0.32, 0.38]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.16 (P = 0.87)							
6 Verbal fluency							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
Total (95% CI)	**114**		**128**			**100.0 %**	**0.16 [-0.09, 0.41]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 1.22$, df = 3 (P = 0.75); $I^2 = 0.0\%$							
Test for overall effect: Z = 1.25 (P = 0.21)							



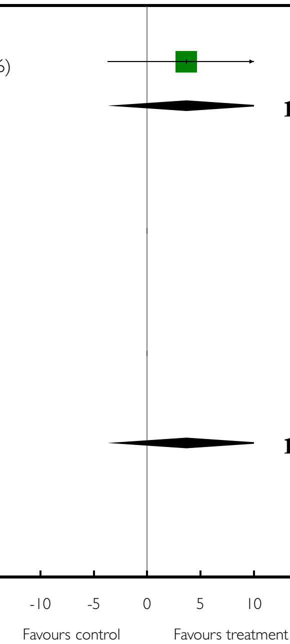
Analysis 3.7. Comparison 3 Aerobic exercise vs. flexibility / balance programme, Outcome 7 Perception.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 3 Aerobic exercise vs. flexibility / balance programme

Outcome: 7 Perception

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
1 Face recognition (delayed recall)							
Kramer 2001	58	75.1 (18.28)	66	71.4 (23.56)		100.0 %	3.70 [-3.68, 11.08]
Subtotal (95% CI)	**58**		**66**			**100.0 %**	**3.70 [-3.68, 11.08]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.98 (P = 0.33)							
2 Ross Information Processing Assessment auditory processing							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
3 Wechsler Adult Intelligence Scales visual reproduction							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
Total (95% CI)	**58**		**66**			**100.0 %**	**3.70 [-3.68, 11.08]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.98 (P = 0.33)							
Test for subgroup differences: Not applicable							



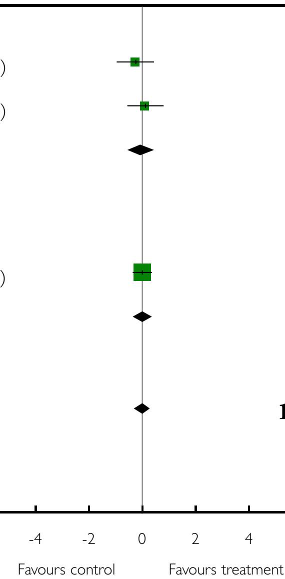
Analysis 3.8. Comparison 3 Aerobic exercise vs. flexibility / balance programme, Outcome 8 Cognitive inhibition.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 3 Aerobic exercise vs. flexibility / balance programme

Outcome: 8 Cognitive inhibition

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Stroop color word (interference)							
Blumenthal 1989 a	15	-2.6 (6.7)	17	-1 (5.4)		16.8 %	-0.26 [-0.96, 0.44]
Blumenthal 1989 b	16	-0.8 (5.9)	17	-1.5 (6.8)		17.5 %	0.11 [-0.58, 0.79]
Subtotal (95% CI)	**31**		**34**			**34.3 %**	**-0.07 [-0.56, 0.42]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.54$, df = 1 (P = 0.46); $I^2 = 0.0\%$							
Test for overall effect: Z = 0.29 (P = 0.77)							
2 Stopping task (accuracy choice RT)							
Kramer 2001	58	93.1 (132.51)	66	92.3 (150.3)		65.7 %	0.01 [-0.35, 0.36]
Subtotal (95% CI)	**58**		**66**			**65.7 %**	**0.01 [-0.35, 0.36]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.03 (P = 0.98)							
Total (95% CI)	**89**		**100**			**100.0 %**	**-0.02 [-0.31, 0.26]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.60$, df = 2 (P = 0.74); $I^2 = 0.0\%$							
Test for overall effect: Z = 0.14 (P = 0.89)							



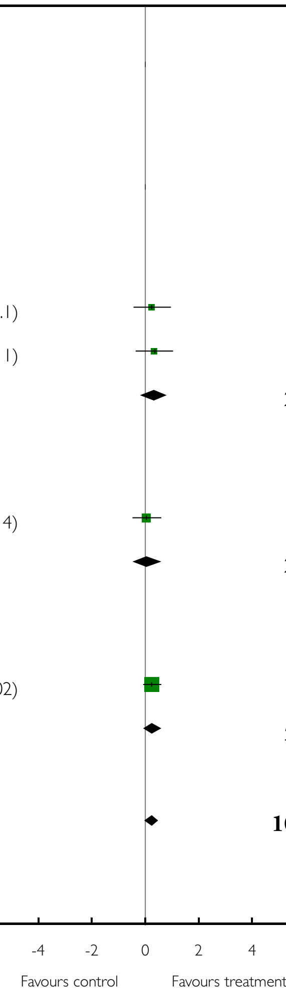
Analysis 3.9. Comparison 3 Aerobic exercise vs. flexibility / balance programme, Outcome 9 Visual attention.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 3 Aerobic exercise vs. flexibility / balance programme

Outcome: 9 Visual attention

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Digit vigilance							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
2 Tracking (accuracy index)							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
3 2%7 test							
Blumenthal 1989 a	15	-6.3 (4.35)	17	-7.85 (7.1)		13.2 %	0.25 [-0.44, 0.95]
Blumenthal 1989 b	16	-7.25 (5.65)	17	-10.35 (11)		13.6 %	0.34 [-0.35, 1.03]
Subtotal (95% CI)	**31**		**34**			**26.7 %**	**0.30 [-0.19, 0.79]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.03$, df = 1 (P = 0.86); $I^2 = 0.0\%$							
Test for overall effect: Z = 1.19 (P = 0.23)							
4 Letter search primary task RT							
Madden 1989	25	-1012.33 (211.26)	28	-1023.67 (248.14)		22.1 %	0.05 [-0.49, 0.59]
Subtotal (95% CI)	**25**		**28**			**22.1 %**	**0.05 [-0.49, 0.59]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.18 (P = 0.86)							
5 Visual search (accuracy)							
Kramer 2001	58	97.75 (3.34)	66	96.95 (3.02)		51.2 %	0.25 [-0.10, 0.60]
Subtotal (95% CI)	**58**		**66**			**51.2 %**	**0.25 [-0.10, 0.60]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.39 (P = 0.17)							
Total (95% CI)	**114**		**128**			**100.0 %**	**0.22 [-0.03, 0.47]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.55$, df = 3 (P = 0.91); $I^2 = 0.0\%$							
Test for overall effect: Z = 1.69 (P = 0.091)							



Analysis 3.10. Comparison 3 Aerobic exercise vs. flexibility / balance programme, Outcome 10 Auditory attention.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

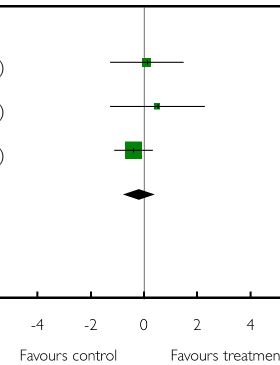
Comparison: 3 Aerobic exercise vs. flexibility / balance programme

Outcome: 10 Auditory attention

Study or subgroup	Treatment N	Treatment Mean(SD)	Control N	Control Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
1 Digit span forward							
Blumenthal 1989 a	15	8 (2.3)	17	7.9 (1.6)		18.7 %	0.10 [-1.29, 1.49]
Blumenthal 1989 b	16	9.8 (2.8)	17	9.3 (2.4)		11.4 %	0.50 [-1.28, 2.28]
Kramer 2001	58	8 (1.98)	66	8.4 (2.11)		69.9 %	-0.40 [-1.12, 0.32]
Total (95% CI)	**89**		**100**			**100.0 %**	**-0.20 [-0.81, 0.40]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 1.07$, df = 2 (P = 0.59); $I^2 = 0.0\%$

Test for overall effect: Z = 0.66 (P = 0.51)



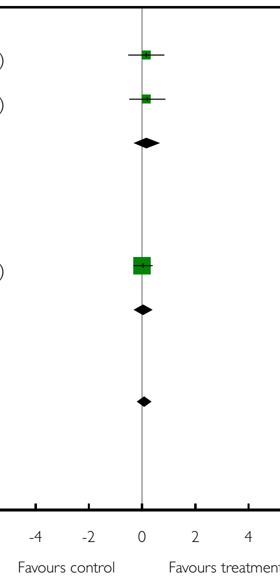
Analysis 3.11. Comparison 3 Aerobic exercise vs. flexibility / balance programme, Outcome 11 Motor function.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 3 Aerobic exercise vs. flexibility / balance programme

Outcome: 11 Motor function

Study or subgroup	Treatment N	Treatment Mean(SD)	Control N	Control Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Finger tapping							
Blumenthal 1989 a	15	115.1 (14.4)	17	112.5 (17.8)		16.9 %	0.16 [-0.54, 0.85]
Blumenthal 1989 b	16	131.6 (14.3)	17	128.2 (19.7)		17.4 %	0.19 [-0.49, 0.88]
Subtotal (95% CI)	**31**		**34**			**34.3 %**	**0.17 [-0.31, 0.66]**
Heterogeneity: Tau² = 0.0; Chi² = 0.01, df = 1 (P = 0.94); I² =0.0%							
Test for overall effect: Z = 0.70 (P = 0.48)							
2 Pursuit rotor task (tracking error)							
Kramer 2001	58	-29.65 (6.25)	66	-29.8 (6.56)		65.7 %	0.02 [-0.33, 0.38]
Subtotal (95% CI)	**58**		**66**			**65.7 %**	**0.02 [-0.33, 0.38]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.13 (P = 0.90)							
Total (95% CI)	**89**		**100**			**100.0 %**	**0.07 [-0.21, 0.36]**
Heterogeneity: Tau² = 0.0; Chi² = 0.25, df = 2 (P = 0.88); I² =0.0%							
Test for overall effect: Z = 0.51 (P = 0.61)							



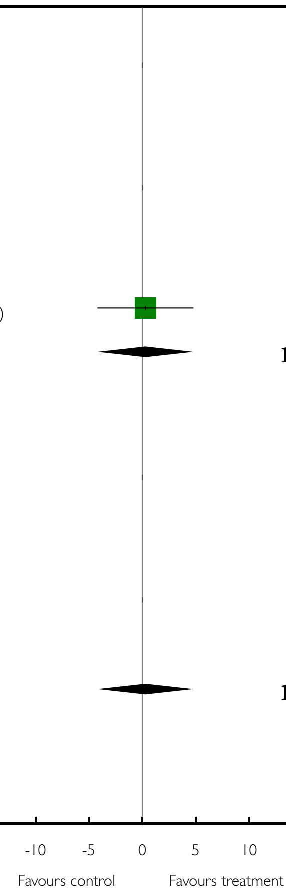
Analysis 4.1. Comparison 4 Aerobic exercise vs. strength programme, Outcome 1 Verbal memory functions (immediate).

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 4 Aerobic exercise vs. strength programme

Outcome: 1 Verbal memory functions (immediate)

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
1 Randt Memory test story recall							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
2 16 words immediate recall							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
3 Ross Information Processing Assessment immediate memory							
Moul 1995	10	23.5 (3.48)	10	23.2 (6.32)		100.0 %	0.30 [-4.17, 4.77]
Subtotal (95% CI)	**10**		**10**			**100.0 %**	**0.30 [-4.17, 4.77]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.13 (P = 0.90)							
4 Wechsler Adult Intelligence Scales logical memory immediate recall							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
5 Rey auditory verbal learning trial I-V							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
Total (95% CI)	**10**		**10**			**100.0 %**	**0.30 [-4.17, 4.77]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.13 (P = 0.90)							
Test for subgroup differences: Not applicable							



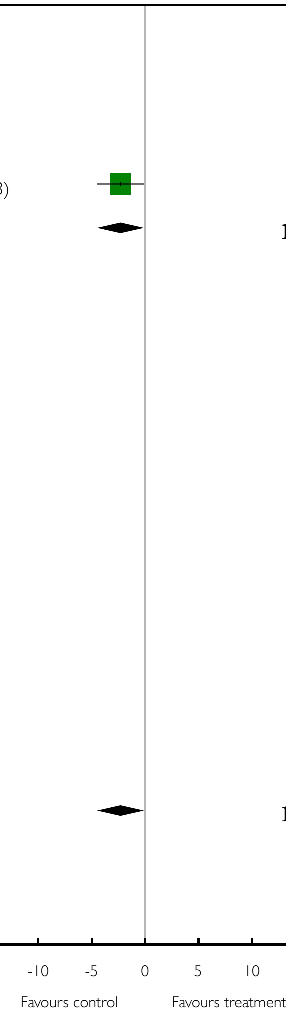
Analysis 4.2. Comparison 4 Aerobic exercise vs. strength programme, Outcome 2 Executive functions.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 4 Aerobic exercise vs. strength programme

Outcome: 2 Executive functions

Study or subgroup	Treatment N	Treatment Mean(SD)	Control N	Control Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
1 Trailmaking part B							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
2 Ross Information Processing Assessment problem solving and abstract reasoning							
Moul 1995	10	27.3 (3.48)	10	29.6 (0.63)		100.0 %	-2.30 [-4.49, -0.11]
Subtotal (95% CI)	**10**		**10**			**100.0 %**	**-2.30 [-4.49, -0.11]**
Heterogeneity: not applicable							
Test for overall effect: Z = 2.06 (P = 0.040)							
3 Wechsler Memory Scales mental control							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
4 Word comparison (#error)							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
5 Task switching paradigm (accuracy)							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
6 Verbal fluency							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
Total (95% CI)	**10**		**10**			**100.0 %**	**-2.30 [-4.49, -0.11]**
Heterogeneity: not applicable							
Test for overall effect: Z = 2.06 (P = 0.040)							
Test for subgroup differences: Not applicable							



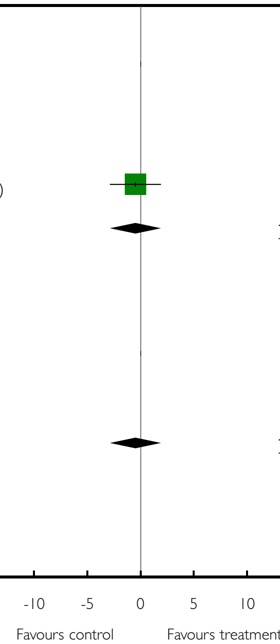
Analysis 4.3. Comparison 4 Aerobic exercise vs. strength programme, Outcome 3 Perception.

Review: Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment

Comparison: 4 Aerobic exercise vs. strength programme

Outcome: 3 Perception

Study or subgroup	Treatment N	Treatment Mean(SD)	Control N	Control Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
1 Face recognition (delayed recall)							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
2 Ross Information Processing Assessment auditory processing							
Moul 1995	10	27.7 (3.8)	10	28.2 (0.95)		100.0 %	-0.50 [-2.93, 1.93]
Subtotal (95% CI)	**10**		**10**			**100.0 %**	**-0.50 [-2.93, 1.93]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.40 (P = 0.69)							
3 Wechsler Adult Intelligence Scales visual reproduction							
Subtotal (95% CI)	**0**		**0**				**Not estimable**
Heterogeneity: not applicable							
Test for overall effect: not applicable							
Total (95% CI)	**10**		**10**			**100.0 %**	**-0.50 [-2.93, 1.93]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.40 (P = 0.69)							
Test for subgroup differences: Not applicable							



ADDITIONAL TABLES

Table 1. CLEAR NPT checklist items

1	Was the generation of allocation sequences adequate?
2	Was the treatment allocation concealed?
3	Were the details of the intervention administered to each group made available?#
4	Were care providers' experience or skill* in each arm appropriate?**
5	Was participant (i.e., patients) adherence assessed quantitatively? ^

Table 1. CLEAR NPT checklist items (*Continued*)

6	Were participants adequately blinded?
6.1.1	If participants were not adequately blinded, were all other treatments and care (cointerventions) the same in each randomised group?
6.1.2	If participants were not adequately blinded, were withdrawals and lost to follow-up the same in each randomised group?
7	Were care providers or persons caring for the participants adequately blinded?
7.1.1	If care providers were not adequately blinded, were all other treatments and care (cointerventions) the same in each randomised group?
7.1.2	If care providers were not adequately blinded, were withdrawals and losses to follow-up the same in each randomised group?
8	Were outcome assessors adequately blinded to assess the primary outcomes?
8.1.1	If outcome assessors were not adequately blinded, were specific methods used to avoid ascertainment bias?§
9	Was the follow-up schedule the same in each group? §§
10	Were the main outcomes analysed according to the intention-to-treat principle?
#	The answer should be "Yes" if these data are either described in the reoprt or made available for each arm (reference to preliminary report, online addendum, etc.)
*	Care provider experience or skill will be assessed only for therapist-dependent interventions (where the succes of the intervention is directly linked to the providers' technical skill. For other treatment this item is not relevant and should be answered "Unclear"
**	Appropriate experience or skill should be determined according to published data, preliminary studies, guidelines, run-in period, or a group of experts and should be specified in the protocol for each study arm before the beginning of the survey
^	Treatment adherence will be assessed only for the treatments necessitating iterative interventions (physiotherapy that supposes several sessions, in contrast to a one-shot treatment such as surgery). For one-shot treatments, this item is not relevant and should be answered "Unclear"
§	The answer is "0" if the answer to 8 is "Yes". The answer should be "Yes" if the main outcome is objective or hard, or if outcomes were assessed by a blinded or at least an independent endpoint review committee, or if outcomes were assessed by an independent outcome assessor trained to perform the measurements in a standardised manner, or if the outcome assessor was blinded to the study purpose and hypothesis
§§	This item is not relevant if follow-up is part of the question. For example, this item is not relevant for a trial assessing frequent versus less frequent follow-up for cancer recurrence. In these situations, this item should be answered "Unclear"

Table 1. CLEAR NPT checklist items (*Continued)*

	For items 6, 7 and 8 a score of 1 was given for a "Yes", a score of 2 for "No, because blinding is not feasible", a score of 3 for "No, although blinding is feasible" and a score of 4 for "Unclear". The other items of the checklist (1-5, 6.1.1., 6.1.2., 7.1.1., 7.1.2., 8.1.1., 9 and 10) were given a score of 1 for "Yes", 2 for "No" and 3 for "Unclear"

Table 2. Grouping of cognitive tests and studies over cognitive functions

Cognitive speed	Simple RT	Panton 1990
	Choice RT	Hassmèn 1997, Whitehurst 1991
	Trailmaking part A	Emery 1998
	Digit symbol substitution	Blumenthal 1989, Kramer 2001, Emery 1990 a
Verbal memory functions (immediate)	Randt memory test story recall	Blumenthal 1989
	16 words immediate recall	Hassmèn 1997
	Ross Information Processing Assessment memory immediate recall	Moul 1995
	Wechsler Adult Intelligence Scales logical memory immediate recall	Fabre 2002
	Rey auditory verbal learning test trail I-V	Kramer 2001
Visual memory functions (immediate)	Benton visual retention	Blumenthal 1989
	Wechsler Memory Scales visual reproduction immediate recall	Fabre 2002
Working memory	Digit span backward	Blumenthal 1989, Kramer 2001
Memory function (delayed)	16 words delayed recall	Hassmèn 1997
	Rey auditory verbal learning test delayed recall trail	Kramer 2001
Executive functions	Trailmaking part B	Blumenthal 1989
	Ross Information Processing Assessment problem solving and abstract reasoning	Moul 1995
	Wechsler Memory Scales mental control	Fabre 2002

Table 2. Grouping of cognitive tests and studies over cognitive functions *(Continued)*

	Word comparison	Madden 1989
	Task switching paradigm	Kramer 2001
	Verbal fluency	Emery 1998
Perception	Face recognition	Hassmèn 1997, Kramer 2001
	Ross Information Processing Assessment auditory processing	Moul 1995
	Wechsler Adult Intelligence Scales visual reproduction	Fabre 2002
Cognitive inhibition	Stroop color word test	Blumenthal 1989
	Stopping task	Kramer 2001
Visual attention	Digit vigilance	Emery 1998
	Tracking	Bakken 2001
	2&7 test	Blumenthal 1989
	Letter search	Madden 1989
	Visual search	Kramer 2001
Auditory attention	Digit span forward	Blumenthal 1989, Emery 1990 a, Fabre 2002, Hassmèn 1997, Kramer 2001
Motor function	Finger tapping	Bakken 2001, Blumenthal 1989, Emery 1998
	Pursuit rotor task	Kramer 2001

Table 3. Methodological quality of included studies (CLEAR NPT score)

Study ID	1 / 2	3	4	5	6 / 6.1.1. / 6.1.2	7 / 7.1.1. / 7.1.2.	8 / 8.1.1	9	10
Bakken 2001	3 / 3	1	3	1	2 / 3 / 2	2 / 3 / 2	4 / 1	1	2
Blumenthal 1989	3 / 3	1	3	1	2 / 2 / 2	2 / 2 / 2	4 / 3	1	3

Table 3. Methodological quality of included studies (CLEAR NPT score) *(Continued)*

Emery 1990 a	3 / 3	1	3	1	2 / 2 / 2	2 / 2 / 2	4 / 3	1	2
Emery 1998	1 / 1	1	3	1	2 / 2 / 2	2 / 2 / 2	1 / 0	1	2
Fabre 2002	3 / 3	1	3	2	2 / 1 / 1	2 / 1 / 1	4 / 3	1	1
Hassmén 1997	3 / 2	1	3	3	2 / 3 / 1	2 / 3 / 1	4 / 3	1	1
Kramer 2001	3 / 3	1	3	1	2 / 3 / 1	2 / 3 / 1	4 / 3	1	2
Madden 1989	3 / 3	1	3	1	2 / 3 / 2	2 / 3 / 2	4 / 3	1	2
Moul 1995	3 / 3	1	3	3	2 / 3 / 1	2 / 3 / 1	4 / 3	1	1
Panton 1990	3 / 3	1	3	2	2 / 3 / 3	2 / 3 / 3	4 / 3	1	2
White-hurst 1991	3 / 3	1	3	2	2 / 3 / 3	2 / 3 / 3	4 / 3	1	3

WHAT'S NEW

Last assessed as up-to-date: 31 January 2008.

Date	Event	Description
10 April 2008	New search has been performed	The delayed memory functions data have been corrected
10 April 2008	New citation required and conclusions have changed	Errors in the data entry for the outcome delayed memory function have been corrected. The effect of physical exercise on this outcome are not statistically significant

CONTRIBUTIONS OF AUTHORS

MA: drafting reviews, searching for trials, obtaining copies of trial reports, selection of included trials and exclusion of trials, extraction and entry of data, interpretation of data analysis.

GA: searching for trials, obtaining copies of trial reports, selection of included trials and exclusion of trials, extraction of data, interpretation of data analysis.

HV: interpretation of data analysis.

AA: interpretation of data analysis.

LV: selection of in-and exclusion of trials, interpretation of data analysis.

Contact Editor: Linda Clare

Consumer Editor: Judith Hoppesteyn-Armstrong

With special thanks to Rob de Bie, editor of Musculoskeletal Group, for his assistance.

DECLARATIONS OF INTEREST

None known.

INDEX TERMS

Medical Subject Headings (MeSH)

Cognition [*physiology]; Cognition Disorders [prevention & control]; Exercise [*physiology]; Memory [physiology]; Oxygen Consumption [physiology]; Physical Fitness [*physiology]; Randomized Controlled Trials as Topic

MeSH check words

Aged; Humans; Middle Aged