Aerobic exercise and neurocognitive performance: a meta-analytic review of randomized controlled trials

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CRD summary
This review assessed the effects of aerobic exercise training on neurocognitive performance, and concluded that it was associated with modest improvements in attention and processing speed, executive function, and memory, but not working memory, in healthy adults. These conclusions are appropriate for healthy older adults, but might not be generalisable to impaired populations.

Authors' objectives
To assess the effects of aerobic exercise training on neurocognitive performance.

Searching
Twelve databases were searched for studies published between January 1996 and July 2009. The databases included PubMed, EMBASE, CINAHL, Cochrane Central Register of Controlled Trials (CENTRAL), PEDro, and PsycINFO and the search terms were specified. Relevant journals (titles and dates not stated) were handsearched and the reference lists of previous meta-analyses were checked. Unpublished dissertations and conference papers were obtained, where possible.

Study selection
To be eligible for inclusion, studies had to: have random treatment allocation; include patients with a mean age of at least 18 years, who were not demented; treat patients for longer than one month; involve aerobic exercise training, such as brisk walking, biking, or jogging; have a control group that did not engage in aerobic exercise; present sufficient information to allow the estimation of effect sizes; and contain at least one of a range of possible outcomes. The outcomes were classified as attention and processing speed, executive function, working memory, or declarative memory, and examples were given. Where required, the authors were contacted for further details.

The publication dates of included studies ranged from 1982 to 2009 and three of them reported that patients had mild cognitive impairment. Where reported, participant age ranged from 16 to 94 years; treatment duration was between six and 72 weeks, with varying frequency and intensity; and attrition ranged from zero to 41%. Some studies had all female populations, while others did not report their participants' gender proportions.

The number of reviewers who selected studies was not stated.

Assessment of study quality
Included studies were assessed, by two reviewers independently, as to whether the assessor was blinded and whether an intention-to-treat analysis was completed.

Data extraction
Two reviewers independently extracted a range of data for the following neurocognitive outcomes: attention, executive function, working memory, and memory. Where a study reported more than one item that corresponded to a particular outcome, the average of these within-study effect sizes was used, even where the items reported were different.

Methods of synthesis
Effect sizes were calculated using Cohen's g, and pooled using both fixed-effect and random-effects models, but only the random-effects outputs were presented. The Q statistic was also calculated to assess statistical heterogeneity. Sensitivity analyses were performed to assess the effects on outcome of trial duration, intensity, mode of exercise, and baseline cognitive status (whether the patient population had mild cognitive impairment), as well as assessor blinding and the use of intention-to-treat analysis.
Results of the review

Twenty-nine studies were included, with over 2,000 participants (range 14 to 187). Seven studies reported intention-to-treat analyses, and 13 reported blinding of assessors.

Individual tests: Pooled statistically significant effects were identified for two tests of executive function: Trail Making Test Section B (Hedges' g 0.234, 95% CI 0.042 to 0.426; five studies) and Animal Naming (Hedges' g 0.275, 95% CI 0.006 to 0.545; four studies). The remaining pooled test results were not statistically significant.

Outcomes: Pooled results found a statistically significant average effect for attention and processing speed (Hedges' g 0.158, 95% CI 0.055 to 0.260; 24 studies), executive function (Hedges' g 0.123, 95% CI 0.021 to 0.225; 19 studies), and memory (Hedges' g 0.128, 95% CI 0.015 to 0.241; 16 studies), but not working memory.

Sensitivity analyses, comparing the results of patients with mild cognitive impairment versus those without, found no statistically significant differences between groups. There was no difference in the effect estimates both with blinding of assessors versus without and with intention-to-treat analysis versus without.

Authors' conclusions

Aerobic exercise training was associated with modest improvements in the neurocognitive functions of attention and processing speed, executive function, and memory, but not working memory, in healthy adults. There was preliminary evidence that adults with mild cognitive impairment might experience greater improvement in memory than those without impairment.

CRD commentary

This review addressed a clear question, using appropriate and clearly specified study selection criteria. The reviewers searched a range of databases, and unpublished material was sought, reducing the risk of publication bias. Sufficient primary study details were provided to make the review transparent. Most of the participants were elderly and the generalisability of the findings to other age groups is unclear. Reporting of the follow-up periods could have increased the transparency of the review. The quality assessment considered only two features, but it was carried out independently by two reviewers, reducing the risk of error and bias. Only one reviewer appears to have selected the studies, increasing the risk of error and bias. The method of synthesis was clearly stated and appears to have been appropriate. In general, the results were clearly reported.

An intervention that clearly provides a health benefit for an impaired population might not provide any or as much health benefit for a non-impaired population. Only three studies reported that participants had mild cognitive impairment; while increased neurocognitive function might be of substantial health benefit for these participants, its benefits for already healthy populations are unclear. The conclusions are appropriate for healthy older adults, but might not be generalisable to impaired populations.

Implications of the review for practice and research

Research: The authors stated that rigorous randomised controlled trials were needed and they should have large samples, appropriate control conditions, and long follow-up periods. Further research should identify a standardised neurocognitive battery of tests, with appropriate psychometric characteristics, and should assess subclinical vascular health as a mediator for the relationship between aerobic exercise and neurocognition. Trials should examine the effects of aerobic exercise training for people with mild cognitive impairments to determine whether this is a plausible strategy to delay dementia.

Practice: The authors did not state any implications for practice.

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