The influence of physical fitness and exercise upon cognitive functioning: a meta-analysis

Etnier J L, Salazar W, Landers D M, Petruzzello S J, Han M, Nowell P

Authors' objectives
To examine the impact that either acute or long-term exercise has on cognition.

Searching
The authors searched the electronic databases of PsycLIT, Educational Research in Completion (ERIC), Dissertation Abstracts, and Completed Research in Education using the keywords: 'cognition', 'cognitive performance', 'mental', 'intellect', 'exercise', 'fitness', 'acute', and 'chronic'. The dates of the search are not reported. Language restrictions are not reported.

Study selection
Study designs of evaluations included in the review
Experimental and quasi-experimental studies of the effects of exercise on cognitive performance in which sufficient data was reported in order to calculate effect sizes for each study.

Specific interventions included in the review
Acute or chronic (long-term) exercise regimes.

Participants included in the review
Male and female participants exercising individually and in groups in age ranges from 6-13 years to 61-90 years.

Outcomes assessed in the review
The improvement of cognitive functioning. The analyses were divided into four subgroups of acute exercise regimes, or chronic exercise regimes, or mixed acute and chronic, or cross-sectional/correlational exercise groupings and the outcomes were measured by cognitive tests which included simple reaction time, line matching tests, verbal comprehension tests, the Culture Fair Intelligence Test, the Stanford-Binet Intelligence Quotient, the Weschler Memory Scale, the Steinberg Number Task, the Stroop test, and Raven's Progressive Matrices Test. In all, there were 106 different cognitive tests used in the included studies.

How were decisions on the relevance of primary studies made?
The authors do not state how the papers were selected for the review, or how many of the authors performed the selection.

Assessment of study quality
There was no formal quality assessment, however the authors coded for variables which might affect their quality, including study design, publication status, sampling method, method of assigning participants, and number of threats to internal validity.

Data extraction
The authors do not state who, or how many of the authors, performed the data extraction.

Each study was limited to one set of effect sizes from one comparison group. Outliers were identified as effect sizes more than 3 standard deviations (SD) from the mean and these effects were excluded from the data combining. Each effect size was multiplied by a correction factor designed to yield an unbiased estimate of effect size.

Methods of synthesis
How were the studies combined?
The individual effect sizes were combined in a statistical analysis of effect sizes using Hedges’ formula (see Other Publications of Related Interest no.1) with mean, standard deviation and p values also reported.

To control for Type I error (deciding there is a difference when there actually is not), the Bonferroni correction was used so that the level of significance was adjusted based on the number of simultaneous analyses. This resulted in the significance level being set at p = 0.002.

How were differences between studies investigated?
The authors examined moderator variables to determine which aspects of a particular study might significantly influence the size of the effect. One-way analyses of variance (ANOVAs) were conducted with corrected effect size as the dependent variable and with the various moderator variables as the independent variables. For the continuous moderator variables, correlational analyses were conducted.

For moderator variables that had a significant impact on the effect sizes, the Scheffe test was used for post-hoc analyses to determine which levels of the variables were significantly different (p < 0.05) from each other and a z statistic was used to determine if the effect size was equal to zero (p < 0.05).

Additional cross-tab analyses to determine third-order causation. The a priori hypotheses were examined using the most appropriate statistical technique.

Results of the review
One hundred and thirty-four (134) studies were included with 1,260 effect sizes for the statistical analyses. The total number of participants is not reported.

The overall mean effect size for all of the studies was found to be 0.25 (SD = 0.69, p < 0.05) which suggests that exercise improves cognitive functioning by a small positive effect of 0.25 standard deviations and that this improvement is statistically significantly different from zero.

The adjusted overall mean (after exclusion of outliers and after taking only the best comparison group from each included study) was 0.29 (SD = 0.63, p < 0.05) which was statistically significant.

The results showed that the effect sizes were largest when a cross-sectional or correlational method was used (ES = 0.53), next largest for a chronic training programme (ES = 0.33) and smallest for an acute bout of exercise (ES = 0.16).

Examination of the moderator variables indicated that characteristics related to the exercise paradigm, the participants, the cognitive tests, and the quality of the study influence effect size.

Authors’ conclusions
This review suggests that both acute exercise and chronic training programmes benefit cognitive performance. However, even the most avid exercise proponent must recognise that the weakness of the design of these studies has resulted in serious limitations about any conclusions regarding the relationship between exercise and cognition, and have also resulted in ambiguity in terms of the nature of the relationship between exercise or fitness and cognition.

CRD commentary
The authors have stated the research question but have not listed any inclusion or exclusion criteria for the review. The literature search is adequate although the dates of the searches are not given and it is not stated whether there were any language restrictions. Hence, it is possible that non-English studies and unpublished relevant studies may have been missed.

The authors have not reported on how the articles were selected or how many reviewers selected the articles and extracted the data. The quality assessment procedure is described but is not rigorous or scored statistically. Individual study details are not given; neither are the number of participants who were included in the review. The studies are
statistically combined using effect sizes which may have been inappropriate because of the variety between the studies and the large number of moderator variables and measurement scales in the individual studies.

The authors mention several methodological drawbacks for the included studies. Since there is insufficient data reported from the individual studies, and about the process of performing this review, so the author's conclusions should be viewed with caution.

**Implications of the review for practice and research**

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

Research: The authors state that since effect size increased with decreased experimental rigour, further research is needed that emphasises experimental rigour.

**Bibliographic details**


**Other publications of related interest**


**Indexing Status**

Subject indexing assigned by CRD

**MeSH**

Cognition; Physical Fitness

**AccessionNumber**

11998008818

**Date bibliographic record published**

30/09/2000

**Date abstract record published**

30/09/2000

**Record Status**

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