Effect of aerobic exercise on blood pressure: a meta-analysis of randomized, controlled trials
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Authors' objectives
To determine the effect of aerobic exercise on blood-pressure.

Searching
MEDLINE was searched from 1966 to September 2001 using the MeSH terms 'exercise', 'physical fitness', 'hypertension' and 'blood pressure', and the keywords 'physical activity' and 'aerobic exercise'. The SPORTDiscus database was searched using the same strategy. The reference lists from original research papers and review articles were examined. Only studies published in English language journals were eligible for inclusion.

Study selection
Study designs of evaluations included in the review
Randomised controlled trials (RCTs) of at least 2 weeks' duration were included.

Specific interventions included in the review
Studies of aerobic physical activity, which lasted for at least 2 weeks, were eligible for inclusion in the review. In most of the included trials, the participants in the control groups were instructed not to modify their usual lifestyle, including physical activity; in some trials, the participants in the control groups were encouraged to participate in monitored reading, discussion, stretching routines or a walking programme. Differences between the treatment and control groups had to be limited to aerobic physical activity.

Participants included in the review
Adults (mean age: 21 to 79 years) were included. Fifteen trials were conducted in hypertensive patients and 28 in normotensive participants. Fifty-one of the 54 included trials were conducted in participants with sedentary lifestyles at baseline. Of the trials which reported the gender distribution, 10 included predominantly men and 17 included predominantly women. Among trials that reported the ethnic distribution, all or most of the participants were white in 23 trials, Asian in 6 trials and black in 4 trials.

Outcomes assessed in the review
Changes in blood-pressure (systolic and/or diastolic) from baseline to follow-up had to be reported, as well as the variances or data to estimate them.

How were decisions on the relevance of primary studies made?
Three of the authors used predetermined selection criteria to identify and independently review articles. Any disagreements were resolved by discussion and, where necessary, by deliberation with a fourth investigator.

Assessment of study quality
The authors do not state that they assessed validity.

Data extraction
Three of the authors used a standardised protocol and reporting form to independently abstract data on the characteristics of the trial participants and study design, the intervention method and duration, and the study outcomes. Where unstated, ethnicity was assumed to be white if the study was conducted in Europe, Australia or New Zealand, Asian if the study was conducted in Asia, and black if the study was conducted in Africa. Differences in duplicate data extraction among the primary reviewers were resolved by discussion and, where necessary, by obtaining additional input from a fourth author. Where variances for the change in blood-pressure were not presented, they were calculated using published methods (see Other Publications of Related Interest nos.1-2).
Methods of synthesis

How were the studies combined?
The estimated mean effect of aerobic exercise on blood-pressure and the associated 95% confidence intervals (CIs) were calculated using fixed-effect and DerSimonian and Laird random-effects models (see Other Publications of Related Interest no.3). The random-effects model was chosen to present the results. Some sensitivity analyses and subgroup analyses were performed. The potential for publication bias was examined using a funnel plot, in which sample size was plotted against the net change in blood-pressure. In addition, a non-parametric 'trim and fill' method was used to test and adjust for potential publication bias (see Other Publications of Related Interest nos.4-5).

How were differences between studies investigated?
The authors state that a random-effects model was used because the trials had significant heterogeneity in effect size, but they do not state how this heterogeneity was measured. They also state that the random-effects model was used because the studies were conducted among participants of different ethnic backgrounds, genders and hypertensive status. A series of pre-stated subgroup analyses were performed to examine the influence of covariables. The subgroups were chosen on the basis of biological plausibility and knowledge of previous studies on the relationship between exercise and blood-pressure. For each subgroup, the pooled effects were calculated using the random-effects model and statistical significance was tested using a one-way analysis of variance.

Results of the review

Fifty-four RCTs (n=2,419) were included.

Aerobic exercise was associated with a significant reduction in the mean systolic and diastolic blood-pressure: -3.84 mmHg (95% CI: -4.97, -2.72) and -2.58 mmHg (95% CI: -3.35, -1.81), respectively. A reduction in blood-pressure was associated with aerobic exercise in hypertensive participants and normotensive participants, and in overweight participants and normal-weight participants.

Publication bias.

A plot of sample size versus effect size for systolic and diastolic blood-pressure showed that several large trials reported a moderate reduction in blood-pressure. However, in a sensitivity analysis using a non-parametric 'trim and fill' method, no study was removed and the overall effect size remained unchanged.

Authors' conclusions

Aerobic exercise reduced the blood-pressure in both hypertensive and normotensive persons. An increase in aerobic physical activity should be considered an important component of lifestyle modification for the prevention and treatment of high blood-pressure.

CRD commentary

The review question and the study selection criteria were stated clearly. The literature search was limited to two databases and to English language publications, which may have led to some studies being missed. The funnel plot suggested some form of publication bias. The validity of the studies does not seem to have been assessed. Details of the review process, such as how many of the reviewers selected the studies, were reported. It was stated that details of the participants and interventions in the individual studies are shown in an appendix, which is available on the Annals of Internal Medicine website; this may be inaccessible to those without a journal subscription.

The authors reported that the random-effects model was used to pool all studies since there was evidence of statistical and clinical heterogeneity. The main analysis and all sensitivity and subgroup analyses all found a statistically-significant benefit of aerobic exercise. However, the degree of heterogeneity and possible sources were not reported in any detail. In addition, no report of whatever heterogeneity remained in the sensitivity and subgroup analyses was made. Therefore, the reader cannot be certain that an important factor was not missed.
The authors' conclusions should be accepted with some degree of caution.

**Implications of the review for practice and research**
Practice: The authors state that while the blood-pressure reduction observed in this review may be of moderate interest to practitioners treating individual patients, a small decrease in the population's average blood-pressure level should dramatically reduce the incidence of and death from cardiovascular disease in communities.

Research: The authors state 'Additional studies are needed to identify ways to improve adherence to exercise and that the effect of physical activity in ethnic subgroups, particularly African-American women, needs further attention'.

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**Other publications of related interest**

This additional published commentary may also be of interest. Elley CR, Arroll B. Review: aerobic exercise reduces systolic and diastolic blood pressure in adults. Evid Based Med 2002;7:170.

**Indexing Status**
Subject indexing assigned by NLM

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