Effects of exercise on glycemic control and body mass in type 2 diabetes mellitus: a meta-analysis of controlled clinical trials


Authors' objectives
To determine the effect of exercise on glycosylated haemoglobin (HbA1c) and body mass in people with type 2 diabetes.

Searching
The following databases were searched up to December 2000: MEDLINE (from 1966), EMBASE (from 1980), SPORTDiscus (from 1949), HealthSTAR (from 1975), Dissertation Abstracts (from 1861) and the Cochrane Controlled Trials Register. The reference lists of major textbooks, reviews and all identified studies were handsearched. Experts were contacted for details of unpublished studies. Non-English language publications were eligible.

Study selection
Study designs of evaluations included in the review
The inclusion criteria were not explicitly defined in terms of study design. Randomised and non-randomised controlled trials (RCTs and non-RCTs, respectively) were included in the review. Eligible studies were subsequently excluded for the following reasons: the interventions alternated between periods of exercise and no exercise; participation in the programme did not significantly increase physical activity; it was not possible to extract results separately for people with and without diabetes; and data were missing.

Specific interventions included in the review
Studies of exercise programmes were eligible if they lasted at least 8 weeks and if participation was verified by direct supervision or through exercise diaries. The exercise programmes had to be defined in advance and the type, frequency, intensity and duration described. Studies of recommendations to exercise, and studies that included cointerventions with drugs, were excluded.

The included studies compared exercise with no exercise control, and exercise plus diet with no exercise and no diet. The exercise interventions were of aerobic exercise and resistance training. They comprised combinations of cycling, jogging, rowing, stair climbing, swimming, treadmill, skiing, weight training, low-impact aerobics and walking. Most of the interventions were of moderate-intensity aerobic exercise using walking or cycling. The exercise sessions took place from two to six times a week, with each session lasting between 30 and 90 minutes; the programmes lasted from 8 to 52 weeks.

Participants included in the review
Studies of adults with type 2 diabetes were eligible for inclusion. The included studies were of patients of different ethnicities. The mean age of the participants (where reported) was 55 years, the mean duration of diabetes was 4.3 years, and 50% of the participants were women. Studies included patients who were already taking insulin and oral hypoglycaemic drugs. During the course of one trial some patients were started on oral hypoglycaemic drugs.

Outcomes assessed in the review
The inclusion criteria were not explicitly defined in terms of outcomes. The primary outcome assessed in the review was HbA1c; other outcomes included body mass.

How were decisions on the relevance of primary studies made?
Two authors independently conducted the searches and resolved any disagreements on the inclusion of trials through discussion with a third author.

Assessment of study quality
Validity was assessed using the 5-point Jadad scale, which considers randomisation, blinding and withdrawals. In addition, the adequacy of concealment allocation was assessed. Two authors independently assessed validity and resolved any disagreements through discussion with a third author.

**Data extraction**

Two authors independently extracted the data. The tabulated information included the study location, characteristics of the participants, the number of participants per treatment group, concomitant medication and/or diet, study design and details of the interventions. Baseline and postintervention means and standard deviations were extracted or estimated from the graphs for each treatment group. The authors of the studies were contacted for missing data. The effect size was calculated for each study; standardised mean differences were used when the same outcome was assessed on different scales.

**Methods of synthesis**

How were the studies combined?
The studies were grouped by treatment comparisons (exercise versus no exercise, and exercise plus diet versus no exercise plus no diet) and analysed separately. A pooled weighted mean difference (WMD) and 95% confidence intervals (CIs) were calculated with weighting by the inverse of the variance for HbA1c and body mass. A fixed-effect model was used. Publication bias was assessed using a funnel plot.

How were differences between studies investigated?
Statistical heterogeneity was assessed using the chi-squared statistic. Where significant heterogeneity was found, the data were to be reanalysed using a random-effects model. Sensitivity analyses were conducted by analysing randomised and non-randomised trials separately, by comparing results for aerobic and resistance training, and after excluding one study that only recruited patients older than 65 years. The relationship between differences in HbA1c and weight loss, exercise intensity, and exercise volume was explored using meta-regression.

**Results of the review**

Fourteen controlled clinical trials (CCTs) were included (504 patients), of which 11 were RCTs (412 patients) and 3 were non-RCTs (92 patients).

Study quality.
The studies were of moderate to low quality (mean Jadad score: 1.6).

**HbA1c.**

Exercise versus no exercise: 9 CCTs (8 RCTs and 1 non-RCT; 11 comparisons; 310 patients) were included. Exercise significantly lowered HbA1c compared with no exercise. HbA1c was 7.65% in the exercise group and 8.31% in the control group; the WMD was -0.66% (95% CI: -0.98, -0.34, P<0.001). No significant heterogeneity was detected (P=0.46).

Exercise plus diet versus no exercise plus no diet: 2 RCTs (3 comparisons; 142 patients) were included. Exercise plus diet significantly lowered HbA1c compared with no exercise plus no diet; the WMD was -0.76% (95% CI: -1.32,-0.20, P=0.008). No significant heterogeneity was detected (P=0.69).

The sensitivity analysis found similar results for randomised compared with non-randomised studies and for aerobic exercise compared with resistance training. The results were similar after excluding one study that enrolled only older patients.

**Body mass.**

Exercise and no exercise: 11 CCTs (8 RCTs and 3 non-RCTs; 13 comparisons; 368 patients) were included. There was no significant difference in body mass between exercise and no exercise; the WMD was 0.06% (95% CI: -0.15, +0.26).
P=0.60). No significant heterogeneity was detected (P=0.95).

Exercise plus diet versus no exercise plus no diet: 2 RCTs (3 comparisons; 142 patients) were included. There was no significant difference in body mass between exercise plus diet and no exercise or diet; the WMD was -0.20% (95% CI: -0.54, +0.14, P=0.24). No significant heterogeneity was detected (P=0.94).

Differences in HbA1c between treatment groups were not significantly related to weight loss, exercise intensity, or exercise volume.

Authors' conclusions
Exercise reduces HbA1c by an amount that should reduce the risk of diabetic complications. Exercise did not have any effect on body mass.

CRD commentary
The review question was clear in terms of the intervention and participants. The inclusion criteria were not explicitly defined in terms of outcomes or study design, though the use of a filter in the search implied that only CCTs were eligible. Subsequently, several studies were excluded and this may have been avoided by the use of tighter inclusion criteria. Several relevant databases were searched, papers in several languages were eligible, and attempts were made to locate unpublished studies. Two reviewers selected the studies, assessed study quality and extracted the data; this reduced the potential for bias and error. Validity was assessed using defined criteria, relevant information on the included studies was tabulated, and characteristics of the individual studies were adequately summarised. The studies were appropriately combined in a meta-analysis and statistical heterogeneity was assessed. Sensitivity analyses were conducted to explore the influence on the results of study design and type of exercise. The evidence presented appears to support the authors' conclusion.

Implications of the review for practice and research
Practice: The authors state that exercise should be looked on as beneficial in its own right for people with type 2 diabetes, independent of any effect on weight.

Research: The authors state that further studies should be well-designed and of longer duration, and should investigate changes in body composition.

Bibliographic details

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Other publications of related interest
This additional published commentary may also be of interest. Franks P, Griffin S. Review: exercise training reduces HbA1c levels but not body mass in type 2 diabetes mellitus. ACP J Club 2002;136:100.

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Record Status
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