Resistance training improves metabolic health in type 2 diabetes: a systematic review
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CRD summary
The authors concluded that resistance training appeared safe for individuals with type 2 diabetes and improved glycaemic control and insulin sensitivity. Neither the methods nor the findings of the review were clearly reported. Overall, the evidence presented did not seem sufficiently strong or consistent to support more than very tentative conclusions.

Authors' objectives
To evaluate the effects of resistance training on glycaemic control and insulin sensitivity in adults with type 2 diabetes.

Searching
MEDLINE, CINAHL and EMBASE were searched. Search dates varied across sources, spanning 1950 to September 2008. Search terms were reported. Reference lists of eligible studies were handsearched. The search was limited to studies published in English.

Study selection
Studies with a resistance training intervention arm were eligible for inclusion, provided they were conducted among adults (aged over 18 years) with type 2 diabetes and that they reported a diabetes marker or an insulin-signalling outcome. Diabetes markers were glycosylated haemoglobin (HbA1c), fasting glucose or insulin and insulin sensitivity. Studies that combined resistance training with another intervention or which had no ongoing training were excluded.

Most participants in the included studies were outpatients living in the community. The mean participant age of most studies was between 50 and 67 years. All participants continued with prior medical interventions. Changes to medication were made only if medically indicated. Most studies provided resistance training by machine, with or without free weights. The volume, frequency and intensity of resistance training varied widely across studies. Most used a whole-body training protocol with progressive increases in exercise volume and/or intensity. Resistance training was usually administered three times weekly; durations ranged from four weeks to 12 months. In some studies, directly supervised resistance training was followed by unsupervised maintenance sessions. Controls received either no exercise intervention or an alternative exercise intervention such as aerobic training. In addition to diabetes markers and insulin signalling, the review reported adverse events, compliance, muscle strength, body composition and cardiac risk factors.

The authors stated neither how the papers were selected for the review nor how many reviewers performed the selection.

Assessment of study quality
The following aspects of study validity were assessed: design; randomisation; allocation concealment; blinding; description of inclusion criteria, intervention and outcomes; reporting of adverse events; group similarity; losses to follow up; statistical methods; and use of power calculation. The authors did not state how the assessment was performed.

Data extraction
Descriptive data for each comparison were extracted and reported in tables, with p values where available. Clinical significance was interpreted as a 0.6 per cent improvement in glycosylated haemoglobin. The authors stated neither how the data were extracted for the review nor how many reviewers performed the data extraction.

Methods of synthesis
Data were not pooled statistically due to clinical and methodological heterogeneity. Studies were combined in a narrative synthesis organised by outcomes and study quality.
Results of the review
Twenty studies (24 articles) were included in the review: 10 randomised controlled trials (n between 614 and 721, duplicate numbers unclear); seven non-randomised controlled trials; and three uncontrolled trials. Sample size among the randomised controlled trials varied from 15 to 251. Only one trial reported adequate allocation concealment. Three trials conducted blinded assessment. Most randomised controlled trials adequately described eligibility criteria, intervention and outcomes measures. Most randomised controlled trials used suitable statistical methods. Only about half reported measures of variability. Only four studies in the review reported sufficient data to permit calculation of effect sizes. Few trials reported how missing data were handled.

Glycaemic control: Two out of nine randomised controlled trials reported clinically relevant reductions in glycosylated haemoglobin of 1 to 1.2 per cent from over 8.0 per cent. Two randomised controlled trials reported that resistance training was as effective or more effective than aerobic training in reducing glycosylated haemoglobin. Improvements diminished during long-term maintenance programmes (two randomised controlled trials). One randomised controlled trial (out of seven) reported a statistically significant improvement in fasting blood glucose level of 3.2 millimoles per litre (which was not evident in controls having aerobic training), but the authors noted clinical differences and possible bias in this study.

Insulin sensitivity: Resistance training significantly improved oral glucose tolerance when compared with sedentary controls (p<0.05, one randomised controlled trial), but not when compared to active controls (one randomised controlled trial). Four out of five randomised controlled trials using homeostasis model assessment to determine insulin resistance reported statistically significant improvements in the resistance training group. Outcomes in these four trials were reported: as changes from baseline (two randomised controlled trials); in comparison with inactive controls (one randomised controlled trial); and in comparison with aerobic training (one randomised controlled trial). One randomised controlled trial using the insulin sensitivity index reported no statistically significant findings.

Insulin signalling (one randomised controlled trial): Muscle glycogen levels improved significantly in the resistance training group compared to controls (p=0.04), but there was no evidence of change in GLUT4 gene or protein expression.

Adverse events (six randomised controlled trials): Hypoglycaemic events were reported in all study groups, but only one case required medical attention. Resistance training appeared to be well tolerated.

Results of other outcomes and of non-randomised trials were also reported in the review.

Authors' conclusions
Resistance training appeared to be safe for individuals with type 2 diabetes and improved glycaemic control and insulin sensitivity.

CRD commentary
The objectives and inclusion criteria of the review were clear. Relevant sources were searched for studies, although the restriction to published studies in English meant that the review was prone to publication and language biases. It was unclear whether steps such as having more than one reviewer independently make decisions on study selection, validity assessment and data extraction were taken to minimise the risk of bias and error in the review. The decision not to combine studies statistically appeared appropriate given their variability. Sources of heterogeneity and potential bias were explored in the text. Relevant criteria were used to assess study validity and the results of the better quality studies (randomised controlled trials) were emphasised. However, the results presented in the review were difficult to follow due to the large number of reported outcomes, the rather confusing layout of the tables and a lack of explanation as to which publications (if any) referred to the same study cohorts. Neither the methods nor the findings of the review were clearly reported. Overall, the evidence presented did not seem sufficiently strong or consistent to support more than very tentative conclusions.

Implications of the review for practice and research
Practice: The authors stated that resistance training may be the exercise of choice for diabetics and prediabetics who found adherence to aerobic training too challenging. Resistance training may need to be performed more than three
days a week, at least initially, to improve diabetic outcomes.

Research: The authors stated that future research in this area should specify exercise protocols, describe the handling of missing data, determine sample size with power calculations and report both short- and long-term outcomes. The minimum dose, optimal regime and setting for resistance training needed to be determined. Studies needed to investigate whether resistance training prescription should be based on insulin sensitivity and examine the mechanisms behind improvements to glucose toleration.

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