Weight-bearing exercise and bone mineral accrual in children and adolescents: a review of controlled trials

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CRD summary
The review investigated the effects of weight-bearing exercise on bone mineral density (BMD) in children and adolescents. The authors concluded that exercise appears to enhance BMD, but it is unclear what type of exercise works best and many studies were of a poor quality. The conclusions follow from the evidence presented, although there were several limitations in the conduct of the review.

Authors' objectives
To evaluate the effects of weight-bearing exercise on bone mineral accrual in children and adolescents.

Searching
MEDLINE and the Cochrane CENTRAL Register were searched up to 2005; the search terms were provided. A search of Google was also undertaken.

Study selection
Study designs of evaluations included in the review
Randomised controlled trials (RCTs) and non-randomised controlled trials of at least 10 participants were eligible for inclusion.

Specific interventions included in the review
Studies of weight-bearing exercise interventions were eligible for inclusion. The interventions in the included studies varied in terms of their frequency, duration and type of exercise. In over half of the studies the exercise sessions were conducted three times per week. The duration of the interventions ranged from 3 to 48 months. Exercise activities included jumping exercises, ball games, gymnastics, aerobics, weight training and circuit training. Some studies included calcium supplementation. Most of the interventions took place in a school setting. The comparators were generally not reported.

Participants included in the review
Studies of healthy children and adolescents (<18 years) who were non-athletes were eligible for inclusion. Studies of mixed maturity groups that did not report the outcomes separately for different groups were excluded. The maturity stage of children in the included studies was classified using Tanner stage: prepubertal, early pubertal and pubertal. A large proportion of the included studies focused on girls.

Outcomes assessed in the review
The primary outcome of interest was dual-energy X-ray absorptiometry-derived bone mineral density (BMD) or bone mineral content (BMC) from the hip, lumbar spine and total body. The secondary outcomes of interest were structural bone parameters.

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

Assessment of study quality
Studies were scored using a scale constructed by the authors that assessed randomisation, loss to follow-up, compliance to the exercise intervention, whether confounding variables were controlled for, duration of trial and sample size. The maximum score was 21: a score of 19 to 21 was classified as having a low risk of bias, 16 to 18 as a moderate risk of
bias, and 15 or below as a high risk of bias. The authors did not state how the validity assessment was performed.

**Data extraction**
The percentage increase in BMC, areal bone mineral density and volumetric BMD in exercisers compared with controls was extracted. The adjusted effect on bone over 6 months duration was also estimated, based on the assumption that the exercise effect is linear over time. Further details were not provided. The authors did not state how the data were extracted for the review, or how many reviewers performed the data extraction.

**Methods of synthesis**
How were the studies combined?
The studies were stratified by stage of maturity and discussed in a narrative synthesis.

How were differences between studies investigated?
Differences between the studies were reported in a table and discussed in the text.

**Results of the review**
Nineteen studies (sample sizes ranging from 10 to 65 per group) were included: 13 RCTs and 6 non-randomised controlled trials.

Nine studies were categorised as having a high risk of bias. Selection procedures, compliance and control of potential confounding variables were identified as particular areas of concern.

Prepubertal children (9 studies).
Six studies reported a statistically significant benefit with the intervention: the difference in bone mass with the intervention ranged from 0.9 to 4.9% over 6 months (adjusted). The quality score ranged from 12 to 20 (i.e. from a high to a low risk of bias). Early pubertal children (8 studies).

The quality score ranged from 13 to 19 (i.e. from a high to a low risk of bias). All of the studies reported a statistically significant improvement with the intervention compared with control: the difference in bone mass with the intervention ranged from 1.1 to 5.5% over 6 months (adjusted). There was some evidence of an exercise-calcium interaction in this maturity group.

Pubertal children (5 studies).

The quality score ranged from 11 to 16 (i.e. from a high to a moderate risk of bias). Two studies reported a statistically significant improvement with exercise: differences in bone mass of 0.3% and 1.9% over 6 months (adjusted).

Results for the secondary outcomes (structural bone parameters) were reported in the paper.

**Authors' conclusions**
Weight-bearing exercise appears to enhance bone mineral accrual in children, particularly during early puberty, but it remains unclear what constitutes the optimal exercise programme. Many studies to date have a high risk of bias and more well-designed studies are needed.

**CRD commentary**
There was a clearly stated review question. Two relevant databases were searched for studies but specific attempts to locate unpublished studies were not made, thereby introducing a risk of publication bias. It was unclear whether there were language restrictions. Standard methods to reduce error and bias in the study selection, data extraction and quality assessment processes were not reported. A detailed quality assessment was conducted, although it had some limitations: concealment of allocation was not assessed for the RCTs and all the criteria were given equal weighting.
From the information provided it was not possible to assess the appropriateness of the adjusted effects calculated. The difference in bone density was reported only for studies that showed a statistically significant benefit leading to a loss of information; this should have been extracted, where available, for all studies as some of the studies may simply be too small to reach statistical significance. While the authors’ conclusions seem reasonable given the evidence presented, there is some uncertainty about their reliability given the limitations outlined.

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

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

**Research:** Well-designed controlled studies investigating the impact of weight-bearing exercise on bone mineral accrual in children and adolescents are required. The most effective type of intervention needs to be identified through investigations of the impact of variations in ground reaction force and exercise frequency. Bone quality should be used as an outcome in addition to bone density.

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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.