Aerobic exercise and bone density at the hip in postmenopausal women: a meta-analysis
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Authors' objectives
To examine the effects of aerobic exercise on bone density at the hip in postmenopausal women.

Searching
Computerised literature searches were performed using MEDLINE (January 1978 to December 1995) as well as cross-referencing from retrieved review articles and original investigations. The following keywords were used either alone or in various combinations for computer searches: exercise, physical activity, physical fitness, bone, bone density, osteoporosis, hip, femur, women, female, postmenopausal and menopause. Only studies published in English language were included.

Study selection
Study designs of evaluations included in the review
Controlled trials (randomised or nonrandomised) with a comparative nonexercise group were included.

Specific interventions included in the review
Aerobic activity only. This included: stationary cycling, ball games, floor work on mats for strength and flexibility, weight bearing exercise, stepping up and down off a 9 inch block 100 times, exercising the upper trunk, and walking. Where stated, exercise was at 60-85% of maximum heart rate, and ranged from 2-4 times per week, and from 15 minutes to one hour.

Participants included in the review
Postmenopausal women. The mean age of participants ranged from 59 to 79 years.

Outcomes assessed in the review
Changes in bone density at the hip. Studies in which bone density was measured at sites other than the hip were not included.

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

Assessment of study quality
The validity of the included studies was not assessed.

Data extraction
All data were extracted by the author, who coded all studies twice, approximately two weeks apart. The coding sheet was then modified until there was agreement between both coding sessions.

Data were extracted under the following categories:

1. Study characteristics.
2. Physical characteristics of participants.
4. Aerobic exercise programme characteristics.

5. Primary outcomes.

**Methods of synthesis**

How were the studies combined?

Effect sizes were calculated by subtracting the before and after difference in the exercise group from the before and after difference in the control group, divided by the control group standard deviation. The variance for each effect size as well as correction for small sample bias was calculated using procedures developed by Hedges (see Other Publications of Related Interest no.1). A fixed-effect model was used to pool effect size data on changes in bone density at the hip. Bootstrap resampling (see Other Publications of Related Interest no.2) was used to generate 95% confidence intervals (CI) around the mean effect size. In addition, nonparametric weights were used to weight effect sizes by sample size (see Other Publications of Related Interest no.3).

For studies that included multiple effect sizes because of more than one group and/or multiple measures of bone density at more than one site, effect sizes were initially treated as independent data points. In order to examine the influence of effect sizes, groups, and studies on overall results, analysis was also performed with each effect size, group, and study deleted from the model.

How were differences between studies investigated?

Heterogeneity of effect sizes was examined using a box plot to identify outliers beyond the 10th and 90th percentiles. Each individual outlier was then examined to see if there was any physiological or methodological reason for their exclusion. If none could be identified, they remained in the analysis.

Subgroup analysis was performed using randomisation tests to examine between group differences (QB) according to study design (randomised versus nonrandomised), type of non-exercise group (calcium versus no calcium), years postmenopausal, age, calcium intake, initial bone and mineral density assessment (dual photon versus dual energy X-ray absorptiometry), total minutes of training (length x frequency x duration) and compliance. With the exception of calcium intake, continuous variables (years menopausal, age, initial bone mineral density, total minutes of training, compliance) were partitioned into two groups according to whether the value was greater than or less than the combined group mean. Calcium intake was partitioned into two groups according to whether the subjects consumed less than, versus greater than or equal to, 1000mg of calcium per day. All effect sizes were calculated using the Meta-Stat (version 1.3; see Other Publications of Related Interest no.4). Mixed effects analysis as well as resampling and randomisation tests were performed using Meta-Win (version 1.0; see Other Publications of Related Interest no. 5).

A funnel plot was used to assess publication bias.

**Results of the review**

Six studies (2 RCTs and 4 controlled non-randomised studies) involving 230 participants (120 exercise, 110 non-exercise) were included. There were a total of 16 groups (8 exercise, 8 non-exercise).

A funnel plot showed no signs of publication bias.

Across all designs and categories, changes in bone density at the hip yielded an average effect size of 0.43 (95% bootstrap CI: 0.04, 0.81). Approximately 67% of the exercise versus nonexercise groups demonstrated benefits. This was equivalent to an overall change of approximately 2.42% (exercise = 2.13; nonexercise = -0.29%) in bone density at the hip.

Examination of outliers beyond the 10th and 90th percentiles revealed four outliers. However, since individual inspection of each outlier revealed no physiological or methodological reason for their exclusion, they remained in the analysis.

The influence of each of the effect sizes or groups of effect sizes on the pooled data was also examined. With each of the 18 effect sizes deleted from the meta-analyses, changes ranged from 0.33 to 0.53. When effect sizes from each of...
the eight groups (8 exercise, 8 nonexercise) were deleted, changes ranged from 0.37 to 0.53.

Subgroup analysis: Studies conducted in the United States had effect sizes that were significantly larger than those conducted in other countries. A statistically significant difference was also found between calcium intake, with larger effect sizes observed among subjects consuming more than 1000mg of calcium per day. While not statistically significant, there was a trend for larger effect sizes to be derived from nonrandomised versus randomised trials. No statistically significant differences were observed when effect sizes were partitioned according to:

1. Whether an exercise plus calcium group was matched with a nonexercise plus calcium group.
2. Years past menopause.
3. Age.
4. Initial bone density.
6. Total minutes of training.
7. Compliance.

Authors' conclusions
The overall results of this study suggest that site specific aerobic exercise has a moderately positive effect on bone density at the hip in postmenopausal women. However, a need exists for additional well designed studies before a final recommendation can be made regarding the efficacy of aerobic exercise as a non-pharmacologic intervention for optimising bone density at the hip in postmenopausal women.

CRD commentary
The review focused on a well defined question. Sufficient details of the individual studies were given, and the studies were combined appropriately.

Although no evidence of a publication bias was found, the search could have been extended to include an attempt to identify unpublished material. In addition, some handsearching could have been performed to identify articles not found in the database search. The inclusion criteria were stated. These seemed appropriate with the exception of the criteria stating that only studies published in English language journals would be included. Few details were given of methods to assess relevancy, for instance the number of authors that were involved in this process was not stated. Excluding foreign language papers may result in important information being missed. The validity of included studies was not assessed, which means that inappropriately high weighting may have been given to methodologically poor studies.

The conclusions follow from the results.

Implications of the review for practice and research
Practice: The author suggests that it would appear plausible for women at risk for osteoporosis to undertake aerobic exercise in conjunction with some type of pharmacologic intervention for enhancing bone density at the hip.

Research: The author states that future studies should include sufficient information on the study design, assessment of bone density, physical characteristics of the participants and training programme characteristics.

Future studies should also focus on the relationship between site-specific aerobic exercise, changes in bone density, and fracture risk. In addition, the effects of more weight-bearing types of exercise (e.g. progressive resistance training) on changes in bone density at the hip need to be investigated.
Bibliographic details

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Other publications of related interest

Indexing Status
Subject indexing assigned by NLM

MeSH
Absorptiometry, Photon; Aged; Bone Density /physiology; Calcium /therapeutic use; Calcium, Dietary /administration & dosage; Effect Modifier, Epidemiologic; Exercise Therapy /methods; Female; Femur /physiology /radionuclide imaging; Hip Joint; Humans; Middle Aged; Postmenopause /physiology; Research Design

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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.