A meta-analysis of impact exercise on postmenopausal bone loss: the case for mixed loading exercise programmes
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CRD summary
This review concluded that mixed loading exercise interventions and resistance training interventions appeared to be effective in preserving bone mineral density at the hip and spine in postmenopausal women. Given the limitations of the quality of the trials, the potential for bias in the review, and the limitations of the subgroup analyses, the authors’ conclusions should be interpreted with caution.

Authors’ objectives
To assess the effects of different impact exercise interventions on hip and spine bone mineral density in postmenopausal women.

Searching
EMBASE, PubMed, Web of Science, SPORTDiscus, EBM Reviews, and ProQuest were searched for published and unpublished trials, from inception to March 2008, without language restrictions. Search terms were reported and six relevant peer-reviewed journals (1986 to 2008) and reference lists of relevant reviews and articles were manually searched. Internet searches were carried out using Google and cross-referencing was undertaken.

Study selection
Controlled trials that assessed the effects of any ground reaction force generating impact activity, including activities where both feet lost contact with the ground, in sedentary postmenopausal women, were eligible for inclusion. The primary outcome of interest was bone mineral density (a surrogate marker for fracture) at the lumbar spine, femoral neck, and whole hip as measured by radiography. Trials including additional forms of skeletal loading exercise, such as resistance training, were eligible.

Included trials were predominantly of Caucasian women with mean ages ranging from 52 to 72.9 years. The median number of years after menopause was 5.2 (range one to 14 years). Some perimenopausal women were included and some participants were receiving hormone replacement therapy (HRT). Trials compared impact exercise with a non-exercise control group. Interventions were categorised as high impact (e.g. vertical jumps, rope jumping, or running at over 9km per hour), odd impact (e.g. aerobic or step classes, or agility classes), low impact (e.g. jogging at under 9km per hour), or combined impact (impact activity mixed with high-magnitude joint reaction force loading through resistance training). Most of the trials reported that all exercise sessions were supervised and exercise regimens ranged from once a week to five days a week, with most of them lasting between six and 12 months.

The authors did not state how many reviewers performed the study selection.

Assessment of study quality
The quality of the trials was assessed using the Jadad scale, which includes criteria on randomisation, blinding, and withdrawals or dropouts. The highest possible score was five.

The authors did not state how many reviewers performed the validity assessment.

Data extraction
Two reviewers independently extracted the absolute change in bone mineral density values from baseline to follow-up, and their standard deviations. Where the absolute change was not reported, the mean change and standard deviation were calculated from baseline and follow-up data. For trials with more than one active intervention arm, participants in the control group were divided equally between treatment groups.
Interventions were categorised as high impact, odd impact, low impact, or combined impact (see Study Selection). The authors did not state how discrepancies were resolved.

**Methods of synthesis**

Random-effects and fixed-effect models were used to combine the mean differences, weighted by the inverse of the variance, and to calculate the weighted mean difference.

Statistical heterogeneity was assessed using the Cochran Q and $I^2$ statistics. Where there was evidence of heterogeneity, the results of the random-effects model are reported.

Predefined subgroup analysis assessed the potential impact of different skeletal loading characteristics of the interventions (high, odd, low, or combined impact) on the treatment effects. Sensitivity analysis was undertaken to investigate the influence of trial design and by excluding the trial that included perimenopausal women.

Publication bias was assessed through a visual inspection of funnel plots.

**Results of the review**

Fifteen trials; 10 randomised controlled trials (RCTs) and five controlled trials were included. It was unclear how many women were recruited, but 1,167 women were analysed at follow-up. The sample sizes ranged from nine to 266 women. One RCT scored three on the Jadad scale, five scored two, and the other trials scored zero or one. Where reported, the attrition rates ranged from 9% to 41%.

**Overall:** There was a statistically significant improvement in bone mineral density in g per cm$^2$ at the lumbar spine (WMD 0.015, 95% CI 0.005 to 0.025; 11 trials; 16 comparisons) and femoral neck (WMD 0.008, 95% CI 0.004 to 0.013; 13 trials; 19 comparisons) using impact exercise interventions compared with control. There was evidence of statistical heterogeneity for both outcomes ($I^2=84\%$ for lumbar spine and $I^2=61\%$ for femoral neck). There was also a significant improvement in hip bone mineral density using impact exercise compared with controls (WMD 0.013, 95% CI 0.001 to 0.024; four trials), but again with statistical heterogeneity ($I^2=91\%$).

**Subgroups:** Subgroup analyses showed that combined-impact interventions significantly improved bone mineral density at the lumbar spine (WMD 0.016, 95% CI 0.005 to 0.027; three comparisons) and femoral neck (WMD 0.005, 95% CI 0.001 to 0.010; five comparisons). There was evidence of statistical heterogeneity for lumbar spine ($I^2=73\%$), but not for femoral neck ($I^2=0\%$). Low-impact interventions, which included jogging, walking, and/or stair climbing, also showed significant improvements in bone mineral density at the femoral neck (WMD 0.022, 95% CI 0.014 to 0.030, six comparisons) and lumbar spine (WMD 0.025, 95% CI 0.004 to 0.046; six comparisons). There was no evidence of statistical heterogeneity for trials assessing the femoral neck ($I^2=0\%$), but there was significant heterogeneity for the lumbar spine ($I^2=88\%$). High-impact and odd-impact interventions showed no significant improvements in bone density at either site.

Sensitivity analyses for only RCTs showed no significant findings. Other findings were reported. Publication bias was evident for trials assessing interventions at both sites.

**Authors' conclusions**

Exercise interventions combining jogging with other low-impact activity and interventions mixing impact activity with high-magnitude exercise, such as resistance training, appeared to be effective in preserving bone mineral density at the hip and spine in postmenopausal women.

**CRD commentary**

The review question was clear and was supported by appropriate inclusion criteria. An extensive literature search was undertaken to locate published and unpublished data, without language restrictions, reducing the potential for language and publication bias, but evidence of publication bias was found in the funnel plots. Validity was assessed using published criteria, but the quality of the included studies was moderate to poor and it was unclear whether the assessment was performed by two people. It was also unclear whether study selection was performed in duplicate,
which means that reviewer bias and error cannot be ruled out. The authors acknowledged that there may have been some selection bias in the individual trials and there were methodological differences between trials. This makes it difficult to determine whether it was appropriate to pool the data. The authors did go some way towards investigating potential sources of bias.

Given these limitations and the fact that only a small number of trials were included in the subgroup analyses, with wide confidence intervals reported for some comparisons, and the lack of statistically significant findings from RCTs, the authors’ conclusions should be interpreted with caution.

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

**Practice:** The authors stated that guidelines for the optimum exercise for preserving bone mineral density in postmenopausal women required revision. Interventions including exercises that provided adequate skeletal loading and were directly targeted at specific skeletal sites should be recommended and clearly described. They also suggested that, where appropriate, specific modes of impact activity should be incorporated into well-designed and safe exercise interventions for postmenopausal women.

**Research:** The authors did not state any implications for research.

**Funding**

Not stated.

**Bibliographic details**


**PubMedID**

18981037

**DOI**

10.1136/bjsm.2008.052704

**Original Paper URL**

http://bjsm.bmj.com/content/43/12/898.abstract

**Indexing Status**

Subject indexing assigned by NLM

**MeSH**

Absorptiometry, Photon; Bone Density /physiology; Clinical Trials as Topic; Exercise Therapy /methods; Female; Hormone Replacement Therapy; Humans; Osteoporosis, Postmenopausal /physiopathology /therapy; Patient Compliance; Selection Bias

**AccessionNumber**

12010000191

**Date bibliographic record published**

10/03/2010

**Date abstract record published**

21/04/2010

**Record Status**

This is a critical abstract of a systematic review that meets the criteria for inclusion on DARE. Each critical abstract
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