Data Documentation

Effects of resistance training on bone mineral density and biomarkers of bone metabolism in postmenopausal women: Systematic review and meta-analysis

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Abstract

This document describes data collected in a systematic review aiding at answering the following question: Does a resistance exercise program improve bone mineral density and bone metabolism in postmenopausal women with osteoporosis/osteopenia? The datasets include data used in meta-analysis or quantitative synthesis, the script used in the meta-analysis (R script) and supplementary data addressing search strategy, excluded studies with reasons and the PRISMA checklist.

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Motivation

Global estimates from the International Osteoporosis Foundation show that one in three women and one in five men over 50 years of age will experience osteoporosis-related fractures (Noh et al., 2020). This disease most commonly affects postmenopausal women, with a higher incidence around 40 to 60 years of age when the natural decline in estrogen levels contributes to the imbalance between bone formation and resorption (Yan et al., 2021). Among non-pharmacological therapies, physical exercise plays a prominent role in both the prevention and treatment of osteoporosis. Supervised physical exercise for osteoporosis patients improves functional capacity, muscle strength, balance, coordination, and flexibility, leading to an improvement in quality of life (Radominski et al., 2017). Mechanical loads promote adaptations in bone mass, as well as in its structure and strength (Radominski et al., 2017; Daly et al., 2019). Resistance exercise, also known as strength training or weightlifting, has been proposed as an efficient non-pharmacological therapy to increase BMD in postmenopausal women, particularly those with moderate to high intensity, with two to three sets of eight to twelve repetitions per exercise and a frequency of two to three times per week, although the results are still inconsistent (Daly et al., 2019).

Methodology

The search for studies was built based on the following PICOS: Population/Problem (P) focused on post-menopausal women with the diagnosis of osteoporosis or osteopenia, the Intervention (I) was the strength exercise, the Comparison (C) was the control group (those that did not practice physical activities of any kind, the primary Outcome (O) was the bone mineral density, and the type of Study (S) was the randomized controlled trial.

The search was conducted in the following databases: PubMed/MEDLINE, Embase, Cochrane Database of Systematic Reviews (CDSR), Cochrane Central Register of Controlled Trials (CENTRAL), Physiotherapy Evidence Database (PEDro), Latin American and Caribbean Literature in Health Sciences (LILACS), Web of Science, Sport Discus and Scopus. Open Grey was searched to identify any relevant grey literature. Additionally, the websites of the International Osteoporosis Foundation (IOF) and the International League of Associations of Rheumatology (ILAR) were searched. The clinical trials databases Clinicaltrials.gov, Brazilian Registry of Clinical Trials (ReBEC) and International Clinical Trials Registry Platform (ICTRP) were searched for registers of clinical trials. Finally, the references of the included studies were also searched.

The inclusion criteria involved:

Population/Problem (P):

Inclusion criteria: Women diagnosed with non-traumatic and post-menopausal osteoporosis or osteopenia according to the classification of the International Osteoporosis Foundation (Cooper and Ferrari, 2019). These conditions are defined by bone densitometry exam, which adopts a T-score of bone mass density (BMD) between -1 and -2.5 to classify the condition as osteopenia and a T-score $\leq$ 2.5 to classify it as osteoporosis.

Intervention (I):

Inclusion criteria: Resistance exercise or traditional strength exercise protocols (weight training) with a minimum frequency of twice a week and intervention time equal to or higher than eight weeks.

Comparison (C):

Inclusion criteria: Control groups that did not involve any physical exercise with known stimulation of bone metabolism.

Outcome (O):

Inclusion criteria: The main outcome was the bone mineral density and biomarkers of bone metabolism. Secondary outcomes could involve C-terminal telopeptide (CTX), bone alkaline phosphatase, osteocalcin, calcium and adverse effects (muscle pain or discomfort and musculoskeletal injuries).

Study Type (S):

Inclusion criteria: Pilot searches prior to protocol registration revealed that randomized controlled trials could potentially provide sufficient data for meta-analysis of the primary outcome. Therefore, our focus was restricted to randomized controlled clinical trials.

A data extraction worksheet was adapted to include data pertinent to this study. The data extracted included the publication year, authors and affiliation, country, study title, journal, protocol registration, funding, study design, number of centers involved, study duration, eligibility criteria, participant age at baseline, number randomized, number assessed, description of the intervention, intervention frequency (x/week), intensity (maximum repetition – MR), duration (minutes), outcomes, risk of bias, whether the study calculated sample size, conflict of interest, data management by the review authors and any other relevant information from the primary study. To determine the muscle strength, we considered the force required for one maximum repetition (1MR). The intensity of the strength training was expressed as the percent of force required for 1MR. It was categorized as low when the force was < 50% of 1MR, moderate when varying from 60 to 80% of 1MR and intense or very intense when > 80% of 1MR.

Data displayed graphically were extracted using an image management software (Image J, National Institutes of Health – NIH, USA). The length calculation resource estimated the mean and standard deviation from bar charts. When the mean and standard deviation of the deltas were not available, they were calculated following the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions (Higgins and Deeks, 2019). Data measured in different regions of the same body part (ex. trochanter, intertrochanter and Ward's triangle of the femur) were grouped to represent the total measure of that part. Similarly, BMD measures from different body parts of the same individual were grouped to represent the global BMD measure of that individual (Higgins and Deeks, 2019). Sample sizes were adjusted in the groups aiming to maintain the sample unit. Also, the standard deviation of the change within the experimental group was calculated.

The primary outcome was bone mineral density (BMD), which is measured by the T-score of the bone densitometry test and expressed in g/cm2. The difference in BMD between the groups after the interventions was expressed as a continuous variable, generating a mean difference (MD) and a 95% confidence interval (95% CI) as a measure of effect in the meta-analysis.

As secondary outcomes, CTX-I (expressed in ng/ml-1), alkaline phosphatase (expressed in IU/l), osteocalcin and calcium (mg/dl) were analyzed. These outcomes were also analyzed, when present, as DM and 95% CI.

Adverse effects, which could involve post-exercise musculoskeletal pain, fall during exercise, lack of desire to return to the protocol were analyzed as dichotomous variables and, when present and properly described, were analyzed as risk ratio (RR) and 95% CI.

When it was not possible to perform meta-analysis, data were analyzed descriptively. The meta-analysis of continuous data was conducted in a paired manner using the inverse variance method, assuming the random effects model. Heterogeneity was assessed considering the I^2 statistic and the visual interposition of the 95% confidence intervals of the studies among themselves. The parameters of intensity, frequency and volume of physical exercise, in addition to the place where the results were obtained (part of the body) would be used in subgroup analyzes when statistical heterogeneity was greater than 50%. The data were analyzed with the 'meta' package of the R software.

Subgroup meta-analysis was planned in the presence of substantial heterogeneity (higher than 50%), considering the location of the body where the bone mass density was measured, parameters of intensity, frequency and volume and the total time of the intervention protocol.

Components of the dataset

Three datasets are available for quantitative synthesis in the systematic review: BMD_total.xlsx addressing the total bone mineral density of the body, CTX_I.xlsx addressing the amount of C-terminal telopeptide I and alkaline_phosphatase.xlsx addressing the amount of alkaline phosphatase. The datasets are composed by the following variables:

Study – Characterization of the study (author/year);

t_n – number of participants in the treatment group;

t_mean – mean produced by the treatment group;

t_sd – standard deviation produced by the treatment group;

c_n – number of participants in the control group;

c_mean – mean produced by the control group;

c_sd – standard deviation produced by the control group.

The R script (script_meta-analysis.R) presents the code used to analyse data from the datasets previously described.

About the project

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The authors declare that they have no conflict of interest of any nature or kind.

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