Progressive resistance exercise and resting blood pressure: a meta-analysis of randomized controlled trials
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Authors' objectives
To use a meta-analytic approach to examine the effects of progressive resistance exercise on resting systolic and diastolic blood-pressure (SBP and DBP, respectively).

Searching
Studies published and indexed between January 1966 and December 1998 were sought through searches of MEDLINE, EMBASE, Current Contents, SPORTDiscus and Dissertation Abstracts International. In addition, the reference lists of retrieved articles were reviewed and two experts on exercise and BP reviewed the authors' reference list for thoroughness and completeness. Journal articles, dissertations and masters theses published in English were sought.

Study selection

Specific interventions included in the review
Studies in which progressive resistance exercise was the only intervention and in which training lasted a minimum of 4 weeks were eligible. The intervention groups in the included studies were: exercise, exercise (normotensives), exercise (hypertensives), exercise (high intensity), exercise (moderate intensity), exercise (low intensity), exercise (supine), and exercise (sitting). The control groups in the included studies were: control, control (normotensives), control (hypertensives), control (supine), and control (sitting). The mean length of training in the included studies was 14 weeks, (standard deviation, SD=6, range: 6 to 30); the mean frequency was 3 times per week (SD=1, range: 2 to 5); the mean intensity was 35% of one repetition maximum (SD=7, range: 30 to 90); the mean duration was 38 minutes/session (SD=14, range: 20 to 60); the mean number of sets per exercise session was 2 (SD=1, range: 1 to 4); and the mean number of exercises performed was 10 (SD=3, range: 6 to 14).

Participants included in the review
Studies of adults (18 years or older) were eligible. Where reported, the mean initial SBP of the included studies ranged from 98.7 (SD=8.7) to 153 (SD=7) mmHg, while the mean initial DBP ranged from 57.2 (SD=5) to 95.8 (SD=6.4) mmHg.

Outcomes assessed in the review
Studies assessing resting SBP and/or DBP were eligible. These were the primary outcomes of interest in the review. The secondary outcomes included changes in body weight, body mass index, percentage body fat, lean body mass, maximum oxygen consumption, and resting heart rate.

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

Assessment of study quality
A 3-item questionnaire developed by Jadad was used to assess study quality on the basis of randomisation, blinding, and withdrawals or drop-outs. The authors do not state how the papers were assessed for quality, or how many of the reviewers performed the quality assessment.
Data extraction
Two authors independently extracted all the data using a 241-item coding sheet developed by the authors. The authors then met and reviewed every extraction item for accuracy and consistency. Any disagreements were resolved by consensus. The data extracted related to characteristics of the following categories: study, participants, BP assessment and exercise programme.

Methods of synthesis
How were the studies combined?
A fixed-effect model was used if the results were homogeneous, while a random-effects model was used if heterogeneity was present. Pooled effect sizes were calculated along with 95% bootstrap confidence intervals (BCIs). Publication bias was assessed using the Kendall rank correlation test.

How were differences between studies investigated?
Heterogeneity was examined using the Q statistic. Sensitivity analyses were performed in which each study was deleted from the model. Cumulative meta-analyses, ranked by year, were performed for net changes in resting SBP and DBP. Subgroup analyses using ANOVA-like procedures for the meta-analysis were performed for study quality and the following categorical variables: source of publication, country of study, hypertensive or not, type of BP instrument, position of participant when BP assessed, and type of training programme. A subgroup analysis was also performed for studies specifically testing the hypothesis of progressive resistance exercise on BP compared with those that were not.

Results of the review
Twelve RCTs met the inclusion criteria. However, 11 RCTs (n=320; 182 exercise, 138 control) were included in the final analysis, as missing BP data could not be obtained for one study.

From the 11 RCTs included in the final analysis there were a total of 14 exercise and 12 control groups, from which a total of 15 primary outcomes were generated.

The mean study quality was two (SD=1, range:1 to 3).

Across all designs and categories, decreases of about 2% and 4% were found for resting SBP and DBP, respectively; the mean decrease was -3 mmHg (95% BCI: -4, -1) for both SBP and DBP. No statistically-significant heterogeneity was found for resting SBP (Q=15.89, P=0.32) or DBP (Q=14.42, P=0.42).

With each study deleted from the model once, the changes ranged from -2 to -3 mmHg for resting SBP and from -2 to -4 mmHg for resting DBP. Cumulative meta-analyses ranked by year showed that these changes had remained constant over time.

There were small, but statistically-significant, decreases in percentage body fat and statistically-significant increases in lean body mass. No statistically-significant differences were found for body weight, body mass index, maximum oxygen consumption, or resting heart rate.

No statistically-significant differences were observed when changes in resting SBP and DBP were partitioned or regressed according to the following characteristics: study, BP assessment, physical characteristics and training programme characteristics.

When limited to study results that appeared in journals, no publication bias was found for changes in either resting SBP or DBP.

Authors’ conclusions
Progressive resistance exercise was efficacious for reducing resting SBP and DBP in adults. However, there is a need for additional studies, which limit enrolment to hypertensive participants and analyse the data using an intention-to-treat approach, before the effectiveness of progressive resistance exercise as a non-pharmacological intervention can be determined.
CRD commentary
The review question was clearly stated and was well supported by a priori defined inclusion criteria relating to the study design, participants, intervention and outcomes. Information on how the primary studies were selected for relevance was not reported, therefore it is not possible to determine how rigorous this process was. Several databases were searched for relevant studies and reference lists were checked. However, the search was restricted to English language articles only, there was no attempt to identify unpublished literature and the search terms were not reported. The quality of the included studies was appropriately assessed, although information relating to how this was done was not reported. Relevant details of the included studies were tabulated clearly, and the data extraction was rigorous and performed by two independent reviewers. The data were appropriately pooled using a quantitative synthesis and heterogeneity was assessed. The authors’ conclusions are supported by the findings.

Implications of the review for practice and research
Practice: The authors did not state any implications for practice.

Research: The authors stated that additional definitive research on stage 2+ hypertensives is required. Future studies need to limit enrolment to participants initially classified as hypertensive, and the inclusion of persons with isolated systolic hypertension would also seem warranted. The inclusion of antihypertensive medication use, and its potential interaction, should be considered in future study designs. Future studies interested in the independent effects of progressive resistance exercise on resting BP should withdraw all participants from antihypertensive medications before participation in the study. In addition, it is important that clinical trials examining the effects of progressive resistance exercise on resting BP in adults analyse data using an intention-to-treat approach and include an examination of the effectiveness of such an intervention.

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