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ORIGINAL ARTICLE

Effect of isometric exercise on resting blood pressure: a meta analysis

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Dynamic physical exercise (walking, swimming, and so on) is an important component of lifestyle changes to reduce blood pressure; however, many individuals are unwilling or unable to adopt this lifestyle change. Isometric exercise has not traditionally been recommended as an alternative to dynamic exercise and has not been well studied. A meta-analysis of controlled trials of isometric exercise on resting blood pressure was therefore undertaken. Five trials were identified including a total of 122 subjects. Isometric exercise for <1 h per week reduced systolic blood pressure by 10.4 mm Hg and diastolic blood pressure by 6.7 mm Hg. These changes are similar to those achieved with a single pharmacological agent. These results suggest that isometric exercise may be of value as part of lifestyle advice in maintaining a desirable blood pressure.
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Introduction

The relationship between blood pressure and risk of stroke and other cardiovascular events is continuous down to a systolic blood pressure of 115 mm Hg; each 20 mm Hg increment of systolic blood pressure doubles the risk of such events across the entire blood pressure range from 115/75 to 185/115 mm Hg.[1] Thus, the risk of an event in subjects with high normal systolic blood pressure (130–139 mm Hg) is double that of subjects with optimal systolic blood pressure (<120 mm Hg). Subjects with high normal blood pressure are at twice the risk of developing hypertension than those with lower values and therefore over time are at greater risk of events and may require antihypertensive medication in the future. Hypertension guidelines[2] emphasize the importance of primary prevention of hypertension for, because hypertension is established, long-term drug therapy is required and despite this the risk of cardiovascular disease events remains greater than in the normotensive population.

Pharmacological treatment is not recommended for individuals with systolic blood pressure <140 mm Hg (130 mm Hg for patients with established cardiovascular disease). Yet it is this population that carries much of the disease burden caused by high blood pressure. For this population the mainstay of treatment is lifestyle advice. Recommended lifestyle changes include weight reduction, abstinence from smoking, a healthy diet and regular physical activity, such as walking, swimming, and so on. Previous meta-analysis has suggested that this type of exercise can reduce systolic and diastolic blood pressures by about 3 mm Hg.[3] Similarly, resistance training can reduce resting systolic blood pressure by ~3 mm Hg.[4] However, such activity is not always embraced with great enthusiasm or may not be easily undertaken by some subjects. For example, lifestyle may limit the time available or an adverse environment may make such activity difficult. Some individuals may be unable to undertake such activity due to comorbidity, for example, obesity, arthritis or lung disease. There is therefore a need for other types of exercise that could be used to lower resting blood pressure, and that may be more acceptable to these individuals.

Isometric exercise (muscle contraction with the generation of a force, but without movement) has traditionally not been recommended for hypertensive subjects. However, there have been small short-term studies in normotensive and hypertensive subjects that have suggested that short periods (10 min or so) of isometric exercise undertaken three to four times a week can lower systolic and diastolic blood pressure. In addition, occupation exposure to isometric exercise is associated with a decreased incidence of hypertension.[5]

Some studies have involved the use of a handgrip device, which displays the force of the isometric

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contraction. Other studies have used double-leg extension on an isokinetic dynamometer. The exercise usually involves exerting force, at a pre-determined proportion of the maximum voluntary contraction, for about 2 min after which there is usually a period of rest. This cycle of exercise and rest is usually repeated three or four times in each exercise session. The purpose of this study was to conduct a meta-analysis of controlled trials reporting the effect of isometric exercise on resting blood pressure.

Methods

The meta-analysis was conducted in accordance with the Quality of reporting of meta-analyses (QUORUM) principles.[6]

The Medline and Sportdiscus databases were searched with the search terms 'isometric' and 'exercise' and 'blood pressure'. Summary data were extracted from eligible trials independently by two of the authors (AO and IS). Any differences were resolved by discussion.

Statistical analysis
A random effects model was used in view of the likely clinical heterogeneity (different types of exercise, different muscle groups, different durations of intervention, different age groups and normotensive and hypertensive subjects) irrespective of any statistical heterogeneity that may be identified. The I^2 measure of heterogeneity[7] was adopted as the commonly used Q-test has poor power when there are few studies.[8] The REVMAN software was used to undertake the analysis and construct the figures. The treatment effect of interest was the difference in change of blood pressure after the intervention, between exercise and control groups.

Results

The literature search was conducted by two of the authors (IS and JW) independently and generated 279 titles for review. Figure 1 summarizes the study selection process. The five selected trials studying 122 subjects formed the basis for the meta-analysis.

Overview of trials
The trials are summarized in Table 1. All trials identified were small (<50 subjects) and of short duration (<10 weeks). Isometric exercises employing handgrip or lower limb extension were used. All trials used three exercise sessions per week, four bouts of 2 min of exercise per session with varying rest periods between bouts. The total weekly exercise time ranged from 33 to 51 min. One of the five trials recruited hypertensive[11] subjects

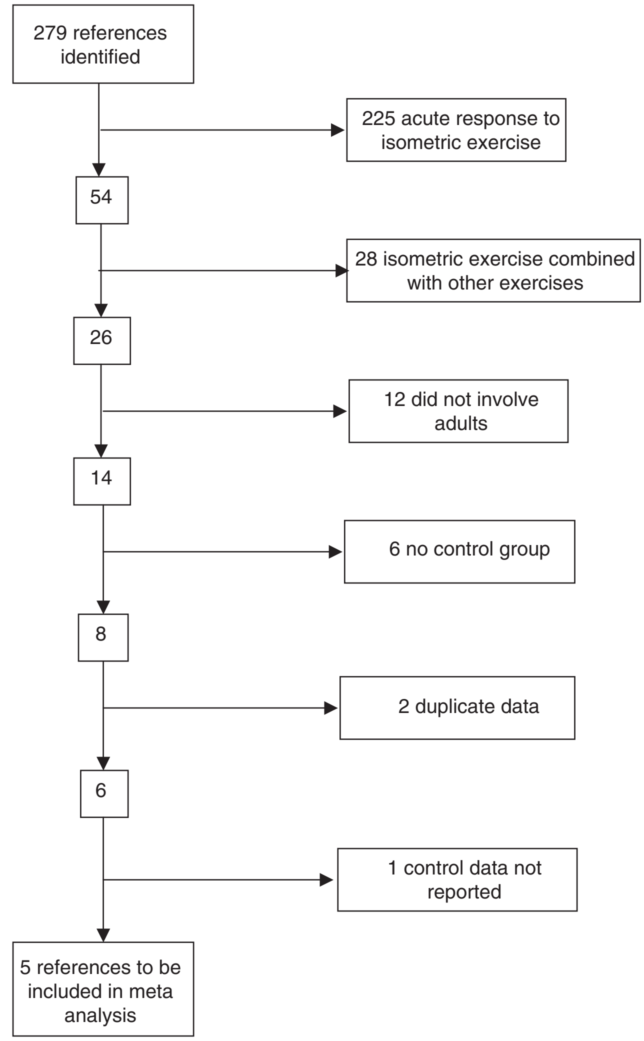

Figure 1 Flowchart of study selection.

and one was not randomized.[13] For obvious reasons none were blinded. In three studies,[9,11,13] the variance of the treatment effect was not reported (and could not be calculated). The authors of these original papers were therefore contacted and this information was requested. For two papers,[11,13] the required information was not available and was therefore estimated[14] using the covariance from another study.[12]

Changes in resting systolic blood pressure
Figure 2 summarizes the effects of isometric exercise on resting systolic blood pressure for the individual trials and the mean overall effect from the meta-analysis. Each trial individually reported a significant reduction in systolic blood pressure with isometric exercise with a mean reduction of 10.4 mm Hg from the meta-analysis. The only study[13] that did not use randomization has the largest treatment effect. Removal of this non-randomized study from the analysis did not meaningfully

Table 1 Summary of trials examining the effect of isometric exercise on resting blood pressure

Study	*Age (years)*	*Type of exercise (% MVC)*	*Duration of study (weeks)*	*Frequency per week*	*No. of bouts/ sessions*	*Duration of bouts/rest (min)*	*Total exercise time per week (min)*
Howden *et al.*[9]	Mean 21	Double-leg extension (20)	5	3	4	2/3	51
Miller *et al.*[10]	64	Handgrip (30–40)	8	3	4	2/1	33
Taylor *et al.*[11]	60–80	Handgrip (30)	10	3	4	2/3	51
Wiles *et al.*[12]	22	Double-leg extension (22)	8	3	4	2/2	42
Wiley *et al.*[13]	29–52	Handgrip (30)	8	3	4	2/3	51

Abbreviation: MVC, maximum voluntary contraction.

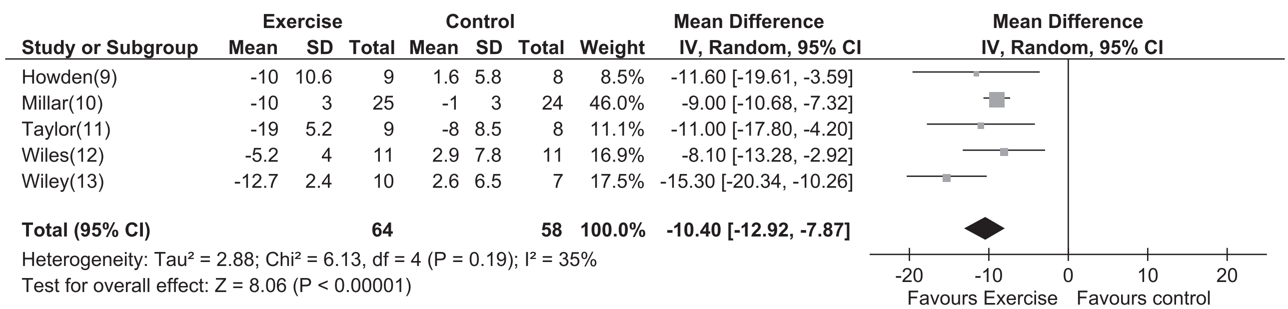

Figure 2 Meta-analysis of trials examining the effect of isometric exercise on resting systolic blood pressure.

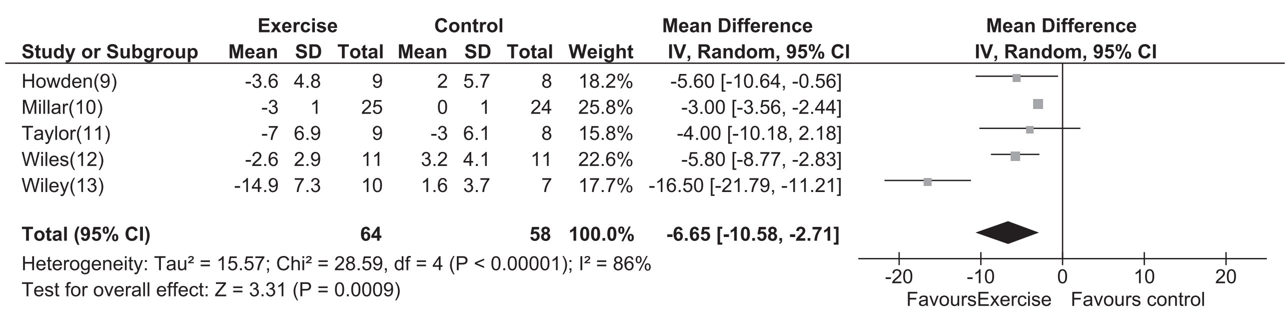

Figure 3 Meta-analysis of trials examining the effect of isometric exercise on resting diastolic blood pressure.

change the outcome (−9.1, 95% confidence interval (−10.6, −7.6) mm Hg), but reduced the value of I^2 to zero, indicating that there is no heterogeneity between the randomized studies.

Changes in resting diastolic blood pressure

Figure 3 summarizes the effects of isometric exercise on resting diastolic blood pressure from the individual trials and the overall effect from the meta-analysis. The only study[13] that did not use randomization has the largest treatment effect. The very high value of I^2 indicates that the vast majority of variance of the treatment effect arises as a result of heterogeneity between studies. Removal of the non-randomized study reduced this to 30%.

Sensitivity analysis

The inclusion of the two smaller trials[11,13] that did not report the variance of the change in blood pressure could potentially bias the findings. An alternative to analysing the change in blood pressure is to use the final blood pressure, which gives similar results, although with less precision, provided the trials are randomized. Unfortunately after excluding the non-randomized trial,[13] and another trial,[10] which did not provide the final blood pressure for the control group, only three trials remained to include in the analysis. For systolic blood pressure, the treatment effect was −6.1 mm Hg (95% confidence interval, −10.4, −1.7), $P = 0.006$, which is consistent with the findings of the main analysis, but based on much less data (56 subjects).

Publication bias
A funnel plot analysis was undertaken and did not show any evidence of publication bias. Intuitively, however, the potential for publication bias would seem high. Any small 'negative' study, that is, a study that did not show a reduction in blood pressure would be unlikely to be accepted for publication (even if it were submitted) because of the small number of subjects and the high risk of a type II error.

Discussion

This meta-analysis suggests that a simple programme of isometric exercise, in bouts of <20 min undertaken three times a week, with a weekly exercise time of <1 h, can reduce systolic blood pressure by about 10 mm Hg and diastolic blood pressure by about 7 mm Hg, in <10 weeks. These are very substantial reductions, comparable with those achieved with a single pharmacological agent and substantially more than the 3 mm Hg or so reduction resulting from regular dynamic exercise[3] or from resistance exercise.[4] The findings from this meta-analysis are based on only five small, albeit consistent studies, including 122 subjects.

The greater reductions in resting blood pressure for isometric exercise compared with other modes of exercise suggest that there might be a more powerful effect on resting blood pressure from isometric exercise. There are a number of possible explanations for this. The type of participant recruited in the various studies, and included in the meta-analyses, is important, particularly the inclusion of studies that have used older hypertensive subjects. In sensitivity analysis, however, after removal of the non-randomized study, there was no between-trial heterogeneity. Thus, indicating that the findings are robust across all age groups and between hypertensive and normotensive subjects.

The present meta-analysis has shown that exercise frequency, duration and number of weeks is less than that reported in the meta-analyses for other modes of exercise. Therefore, total exercise time seems to be less for isometric exercise. It is not possible to compare the exercise intensities of the different types of exercise from published data. Isometric exercise studies involve repeated bouts of exercise with the same isolated muscle group. Therefore, there is the possibility that there is greater local muscle fatigue in this type of training compared with others.

There is potential for important publication bias, with similar studies that did not show an effect on blood pressure either not being submitted for publication or if they were not being accepted. In addition, as clearly, it is not possible to blind this type of study, there is a real possibility of an important placebo effect.

These preliminary findings need to be examined further with larger trials conducted over many months or years. We need to know whether individuals will adhere to a programme of isometric exercise over this time scale, and whether the reductions in blood pressure seen over a few weeks are maintained in the long term. The inability to blind this type of study makes it impossible to exclude a placebo effect. One way of overcoming this limitation is to compare isometric exercise with traditional dynamic exercise. Finally, if these reductions in blood pressure do persist, will they translate into reduced cardiovascular events and complement pharmacological treatments for hypertensive subjects?

What is known about this topic

- Regular dynamic exercise lowers resting systolic blood pressure by about 3 mm Hg and is an integral component of lifestyle advice for patients with hypertension and the general population.

What this study adds

- The limited evidence available suggests that <1 h per week of isometric exercise can lower resting systolic blood pressure by about 10 mm Hg. This seems to be true for hypertensive and normotensive subjects.

Conflict of interest

The authors declare no conflict of interest.

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