Isometric handgrip exercise and resting blood pressure: a meta-analysis of randomized controlled trials

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Objective **: To examine the efficacy of isometric handgrip exercise for reducing resting SBP and DBP in adult humans.**

Methods **: Meta-analysis of studies retrieved from five electronic databases as well as cross-referencing from identified articles. The criteria for inclusion were randomized controlled trials published in any language over an approximate 38-year period (1 January 1971 to 1 February 2009), isometric handgrip training of at least 4 weeks performed by adults of at least 18 years of age, and data for changes in resting SBP and DBP available. Dual coding of studies was performed by both investigators. Data were analyzed *a priori* using random-effects models and nonparametric 95% bootstrap percentile confidence intervals (BCIs, 5000 iterations). Because of the small sample size, analyses were also performed using fixed-effects models *post hoc*.**

Results **: Eighty-one men and women (42 exercise and 39 control) from three of 287 reviewed studies were pooled for analysis. Using random-effects models, statistically significant exercise minus control group reductions of approximately 10% were observed for both resting SBP and DBP (SBP: $\bar{X}$, −13.4 mmHg; 95% BCI, −15.3 to −11.0 mmHg and DBP: $\bar{X}$, −7.8 mmHg; 95% BCI, −16.5 to −3.0 mmHg). Results were also statistically significant when fixed-effects models were used (SBP: $\bar{X}$, −13.8 mmHg; 95% BCI, −15.3 to −11.0 mmHg and DBP: $\bar{X}$, −6.1 mmHg; 95% BCI, −16.5 to −3.2 mmHg).**

Conclusion **: Isometric handgrip exercise is efficacious for reducing resting SBP and DBP in adult humans. However, the generalizability of these findings is limited given the small number of studies included. *J Hypertens* 28:000–000**

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Keywords: blood pressure, exercise, isometric, meta-analysis, physical fitness

Abbreviations: BCIs, bootstrap percentile confidence intervals; IHG, isometric handgrip

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Introduction

Mortality from coronary heart disease as well as stroke and other cerebrovascular diseases in adults is a major public health problem worldwide. For example, the WHO reported that in 2004 the number one cause of mortality was coronary heart disease (7.2 million people) followed by stroke and other cerebrovascular diseases (5.71 million people) [1]. One of the major risk factors for coronary heart disease as well as stroke and other cerebrovascular diseases is hypertension. Not surprisingly, hypertension, defined as an average SBP of at least 140 mmHg, DBP of at least 90 mmHg, or both or use of antihypertensive medication(s), is also a major problem worldwide [2]. Kearney *et al.* [2] reported that the total number of adults with hypertension worldwide was 972 million (26.4%) in 2000. By the year 2025, it is estimated that the number of hypertensive adults will increase by 60% to a total of 1.56 billion [2]. The economic costs associated with hypertension are also high. For example, in the United States, where the most recent prevalence of hypertension has been reported to be 29% in adults 18 years of age and older [3], the costs associated with hypertension in 2009 have been estimated at US $73.4 billion [4].

Lifestyle modifications have consistently been recommended for the treatment and prevention of hypertension [5–8]. One such lifestyle recommendation is exercise, a nonpharmacologic intervention that is available to the vast majority of the general public. Most commonly, aerobic exercises such as walking and bicycling have been recommended for lowering and/or maintaining resting BP. These recommendations are supported by recent meta-analytic research [9] in which statistically significant decreases in resting SBP and DBP were reported in normotensive, prehypertensive, and hypertensive adults as a result of aerobic exercise. Although less recommended, other meta-analytic research [10] has shown that resistance training in which force is applied against an external resistance and significant joint movement occurs as a result of muscle contraction, that is, dynamic resistance training, may also lower resting BP in adults [11]. However, the BP-lowering effects of force applied against a resistance in which muscle contraction occurs but little or no joint movement takes place, that is, isometric resistance training, is less well known [10]. Recently, isometric handgrip (IHG) exercise has been commercially promoted as an approach to lower resting SBP and DBP without pharmacologic intervention [12]. Given these purported benefits, the purpose of this study was to use the meta-analytic approach to examine the efficacy of IHG exercise for reducing resting SBP and DBP in adult humans.

Methods

Data sources

Studies were retrieved by searching five different electronic databases (PubMed, Cochrane Central Register of Controlled Clinical Trials, CINAHL, SPORTDiscus, and Dissertation Abstracts International) as well as cross-referencing from retrieved studies, including review articles. All electronic database searches were conducted by the first author with the assistance of the second author. Although the keywords and combination of keywords varied depending upon the database being searched, terms common to all searches were 'isometric', 'static', and 'blood pressure'. The search query used for PubMed, the database from which the greatest number of citations were derived ($n = 232$), was as follows: isometric AND blood pressure AND random* OR static AND blood pressure AND random* AND {['1971'(EDat): '2009'(EDat)] AND [Humans(Mesh)] AND [adult (MeSH) OR adolescent(MeSH)]}. The term adolescent was included in the query in an attempt to avoid missing any studies that met the investigative teams' age cutpoint ($\geq$18 years).

Study selection

The inclusion criteria for this study were as follows: randomized controlled trials with the unit of assignment at the participant level; an IHG exercise intervention group; IHG exercise of at least 4 weeks in duration; published and unpublished studies (master's theses and dissertations); adults at least 18 years of age; studies published in any language between 1 January 1971 and 1 February 2009; and data available for resting SBP, DBP, or both. The selection of studies was conducted by both authors. Studies were limited to randomized controlled trials because it is the only way to control for confounders that are not known or measured as well as the observation that nonrandomized controlled trials tend to overestimate the effects of healthcare interventions [13,14].

Data abstraction

Prior to coding all studies, a codebook was developed that included information from the following major categories: study characteristics, patient characteristics, IHG exercise characteristics, and outcomes (e.g., changes in resting SBP and DBP). All studies were coded by both authors, independent of each other. They then met and reviewed every item for accuracy and precision. Disagreements were resolved by consensus. Using Cohen's kappa statistic [15], the overall agreement rate (yes/no) prior to correcting discrepant items was 0.88 for the 810 items coded.

Study quality was examined using a previously validated (construct validity, $P < 0.001$) and reliable ($r = 0.77$) three-item scale in which total scores range from zero to five points with higher scores representing greater study quality [16]. The scale focuses on the randomization process as well as blinding and reporting of withdrawals and dropouts. Although a study quality scale was used for this project, it is important to realize that no gold standard currently exists for determining study quality [17]. Consequently, all scales should be interpreted with extreme caution and should probably not be used to weight outcomes [18]. Study quality was assessed by both authors, independent of each other. Using Cohen's kappa statistic [15], the overall agreement rate prior to adjudication was 0.87.

Statistical analysis

Calculation of study-level estimates for resting SBP and DBP

The primary outcomes for this aggregate data meta-analysis were changes in resting SBP and DBP in mmHg. The original metric (mmHg) was used because it is more clinically meaningful [19]. Changes for each study were calculated by subtracting the change score difference in the exercise group from the change score difference in the control group. Variances were calculated from the pooled standard deviations (SDs) of change scores in the exercise and control groups. Change score SDs that were missing for two studies [20,21] were calculated from pre and post-SD values according to procedures developed by others [22]. Each treatment effect was then weighted by the inverse of its variance.

Pooled estimates for resting SBP and DBP

Random-effects models were used *a priori* to pool changes in resting SBP and DBP from each study [23,24]. In addition, fixed-effects models were also calculated *post hoc* because of the small number of studies included. Nonparametric 95% bootstrap percentile confidence intervals (BCIs, 5000 iterations) [25–27] were used to determine statistical significance. If the two-tailed 95% BCIs did not cross zero, results were considered to be statistically significant.

Heterogeneity of outcomes between studies was examined using the Q statistic [28], whereas inconsistency was examined using I^2 [29]. For Q, an alpha value of less than 0.10 was considered to be indicative of statistically significant heterogeneity. For I^2, the decision rule for excessive inconsistency was a value of at least 50%. Generally, I^2 values of 25% to less than 50%, 50% to less than 75%, and at least 75% are considered to represent small, medium, and large amounts of inconsistency [29].

In the absence of statistically significant heterogeneity and inconsistency, no moderator analyses are necessary. Publication bias was examined using the trim and fill approach of Duval and Tweedie [30]. In addition, the influence of each study on the overall results was examined by deleting each study from the model once. All meta-analytic analyses were conducted using Meta-Win (version 2.1; Sinauer Associates, Sunderland, Massachusetts, USA) [31], Comprehensive Meta-Analysis (version 2.2; Biostat, Englewood, New Jersey, USA) [32], and Stata (version 11.0; StataCorp LP, College Station, Texas, USA) [33].

Results

Study characteristics

Eighty-one men and women (42 exercisers and 39 controls) from three [20,21,34] of the 287 studies reviewed met the inclusion criteria. A flow diagram describing the selection of studies is shown in Fig. 1, whereas a general description of each study is shown in Table 1. None of the studies used a crossover design. Overall study quality was scored as 1 for two studies [20,34] and 2 for another [21]. Two studies [20,34] were conducted in Canada and one [21] in the United States. All three studies [20,21,34] appeared to use the per-protocol approach in the analysis of data. One study [21] reported a dropout rate of 20 and 30%, respectively, for the exercise and control groups. Dropouts were the result of participants who missed three consecutive appointments or a total of four appointments [21]. Authors of one study [34] reported that they controlled for attention placebo effects by having control participants engage in weekly one-on-one 10-min discussion sessions related to hypertension. There were no reports of any adverse events as a result of the IHG interventions.

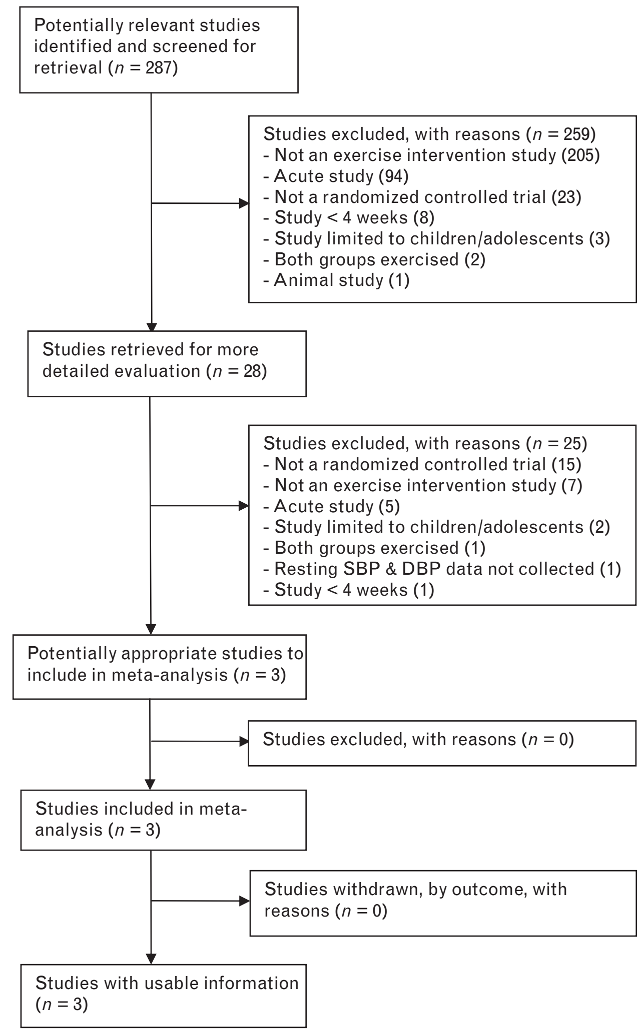
Participant characteristics

Two studies [20,34] included older men and women whose age ranged from 50 to 80 years, whereas the other one [21] included younger participants 20–35 years of age. For the two studies [20,34] that included older participants, all had been recruited from an exercise program in which they had been participating. One study [34] reported that none of the participants were taking any antihypertensive medications, whereas another study [20] reported that 75% of participants were taking one or more of the following: angiotensin-converting enzyme inhibitors, beta-blockers, calcium channel blockers, and diuretics. For cigarette smoking, one study [34] reported that none of the participants smoked while the same study reported that no one was taking any type of hormone replacement therapy, had diabetes, or congestive heart failure.

Training program characteristics

As can be seen in Table 1, two studies [20,34] used a similar IHG training protocol, whereas the other [21] limited training to the dominant arm with a rest period between contractions of 3 versus 1 min. One study [34] used an inexpensive handgrip device for training, whereas the other two [20,21] appeared to use a more expensive device. For those studies that reported data, one [34] reported that exercise took place in both a university setting and at home, whereas the other [21] appeared to have participants train in a university setting.

Fig. 1



Flow chart for the number of publications included and excluded in the meta-analysis, with reasons. The number of reasons for exclusion (368) exceeds the number of excluded publications ($n = 284$) because some studies were excluded for more than one reason.

Assessment of resting blood pressure

A description regarding the assessment of resting blood pressure (BP) is also shown in Table 1. As can be seen, the assessment of BP varied somewhat across the three studies. The mean of at least two measures was used to establish resting BP values for all three studies [20,21,34]. Although all three studies [20,21,34] reported that BP was assessed by the same individual, none reported that the assessor was blinded to group assignment.

Table 1 General characteristics of studies

Reference	Participants (#)	Age (years)	Sex (F/M)	Initial BP status	IHG interventions	Resting BP assessment
Millar *et al.* [34]	Ex: 25, Con: 24	Ex: 66 ± 5.0, Con: 67 ± 9.8	F/M	Normotensive	8 weeks, 3×/week, 4 × 2-min bilateral contractions separated by 1-min rest, 30–40% MVC	Mean of final three of four seated measures using Dinamap Pro 100V2 after 5-min seated rest and alcohol and exercise absence for 24 h
Taylor *et al.* [20]	Ex: 9, Con: 8	Ex: 69.3 ± 6.0, Con: 64.2 ± 5.5	F/M	Hypertensive	10 weeks, 3×/week, 4 × 2-min bilateral contractions separated by 1-min rest, 30% MVC	Mean of three seated measures by auscultation using a standard sphygmomanometer after ≥10-min seated rest and 1-min between measures
Wiley *et al.* [21]	Ex: 8, Con: 7	20–35 (Ex and Con pooled)	NA	Prehypertensive	8 weeks, 3×/week, 4× 2-min dominant arm contractions, separated by 3-min rest, 30% MVC	Mean of two seated measures by mercury sphygmomanometer after ≥10-min seated rest during same time of day; DBP assessed at Korotkoff phase V

Description of groups and participants from each study limited to only those that met the inclusion criteria; unless otherwise noted, age reported as mean ± standard deviation; #, Number; BP, blood pressure; Con, control; Ex, exercise; F, female; IHG, isometric handgrip; M, male; MVC, maximum voluntary contraction; NA, not available.

Blood pressure results

Changes in resting SBP

Initial and final resting values for each study are shown in Table 2, whereas exercise minus control group changes in SBP, both individual and pooled, are illustrated in Fig. 2. For both random and fixed-effects models, statistically significant exercise minus control group reductions of approximately 10% were observed for resting SBP. No statistically significant heterogeneity or inconsistency was observed for either random or fixed-effects models (random-effects: $Q = 1.8$, $P = 0.42$, $I^2 = 0\%$; fixed-effects: $Q = 2.7$, $P = 0.26$, $I^2 = 26.8\%$). In addition, there was no evidence of publication bias, that is, no imputed values were needed. Furthermore, with each study deleted from the model once, results remained statistically significant across all deletions, ranging from −11.0 to −14.8 mmHg.

Changes in resting DBP

Initial and final resting DBP values for each study are also shown in Table 2, whereas exercise minus control group changes in DBP, both individual and pooled, are illustrated in Fig. 2. Statistically significant exercise minus control group reductions of approximately 10% (random-effects model) and 8% (fixed-effects model) were observed for resting DBP. No statistically significant heterogeneity ($Q = 2.2$, $P = 0.33$) or inconsistency ($I^2 = 18.6\%$) was observed when a random-effects model was used, whereas statistically significant heterogeneity ($Q = 25.6$, $P < 0.001$) and inconsistency ($I^2 = 92.2\%$) were observed when a fixed-effects model was employed. No evidence of publication bias was observed. With each study deleted from the model once, results remained statistically significant across all deletions, ranging from −3.3 to −10.3 mmHg.

Discussion

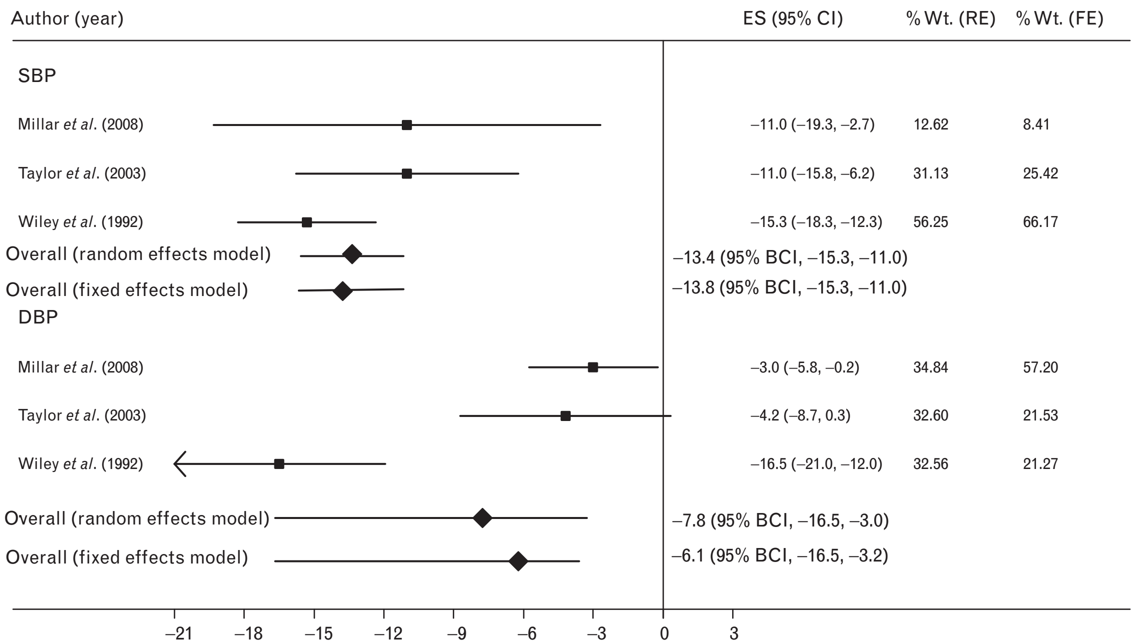
The purpose of this study was to use the aggregate data meta-analytic approach to examine the effects of IHG training on resting SBP and DBP in adult humans. The findings of this investigation support the efficacy of IHG exercise for reducing both SBP and DBP at rest with changes in resting DBP more variable. These results are further supported by the lack of statistically significant heterogeneity and inconsistency observed when a random-effects model was used as well as the absence of publication bias. In addition, the magnitude of the

Table 2 Resting blood pressure results from each study

	Exercise			Control		
Study/variable	Participants (#)	Initial ($\bar{X}$ ± SD)	Final ($\bar{X}$ ± SD)	Participants (#)	Initial ($\bar{X}$ ± SD)	Final ($\bar{X}$ ± SD)
SBP (mmHg)						
Millar *et al.* [34]	25	122.0 ± 14.0	112.0 ± NA	24	117.0 ± 13.7	118 ± NA
Taylor *et al.* [20]	9	156.0 ± 9.4	137.0 ± 7.8	8	152.0 ± 7.8	144.0 ± 11.8
Wiley *et al.* [21]	8	134.1 ± 2.7	121.4 ± 3.8	7	134.0 ± 8.7	136.6 ± 7.4
DBP (mmHg)						
Millar *et al.* [34]	25	70.0 ± 6.5	67.0 ± NA	24	68.0 ± 7.8	68.0 ± NA
Taylor *et al.* [20]	9	82.3 ± 9.3	75.0 ± 10.9	8	87.1 ± 10.8	84.0 ± 9.6
Wiley *et al.* [21]	8	86.5 ± 5.7	71.6 ± 9.7	7	83.4 ± 4.4	85.0 ± 6.4

#, number; $\bar{X}$ ± SD, mean ± standard deviation; NA, not available.

Fig. 2



Forest plot for exercise minus control group changes in resting SBP and DBP in mmHg. The black squares represent the mean exercise minus control group differences from each study, whereas the lines to the left and right of the squares represent the corresponding 95% CIs. The black diamonds represent the pooled exercise minus control group differences, whereas the lines to the left and right of the diamonds represent the 95% BCIs using 5000 iterations. The diamonds do not intersect with the left and right lines equally because bias-corrected 95% BCIs were used. % Wt. (FE), percentage weight contributed by each study for a fixed-effects model; % Wt. (RE), percentage weight contributed by each study for a random-effects model; BCI, bootstrap percentile confidence interval; CI, confidence interval; ES, effect size changes in resting blood pressure in mmHg.

observed changes appears to be clinically important. For example, a 5-mmHg reduction in resting SBP has been associated with a decreased risk in mortality of 9, 14, and 7%, respectively, from coronary heart disease, stroke, and all-causes [35]. Given the reductions in resting SBP observed in the current study, it would appear plausible to suggest that a reduction in the risk of mortality from coronary heart disease, stroke, and all-causes would be more than twice that observed from a reduction of 5 mmHg. The reductions in resting DBP found in the current meta-analysis also appear to be clinically important, with decreases in the relative risk of coronary heart disease and stroke equivalent to as much as 29 and 46%, respectively [36].

Although beyond the scope of this study, the exact mechanisms associated with reductions in resting SBP and DBP as a result of IHG training have not been elucidated. Some of the proposed mechanisms include improvements in markers of oxidative stress [37], decreased tonic sympathetic nerve activity [38], changes in autonomic function towards vagal control [20], ischemia–reperfusion that may mediate oxidative stress [39], and increased systemic shear stress as a result of increased BP and cardiac output during the isometric effort [40]. In addition, the genetic aspects of IHG on changes in resting SBP and DBP need to be explored.

On the basis of our random-effects analyses, the reductions in resting SBP and DBP observed in this aggregate data meta-analysis as a result of IHG exercise are approximately 4.5 (SBP) and 3.3 (DBP) times greater than those observed from a recent meta-analysis [9] that examined the effects of aerobic exercise in studies that included sedentary hypertensive, prehypertensive, and normotensive participants. The results of the present random-effects meta-analysis also represent reductions that are approximately 2.2 (SBP) and 1.7 (DBP) times greater than those reported in another recent meta-analysis [11] dealing with the effects of dynamic resistance training on resting BP. In addition, differences in resting SBP and DBP between IHG training and aerobic and dynamic resistance training might be even greater, given that the current meta-analysis did not include any studies limited to sedentary participants, whereas the aerobic and dynamic resistance training meta-analyses [9,11] were limited to previously sedentary participants. However, this hypothesis needs to be tested in large, randomized controlled trials. More specifically, it would seem appropriate to suggest that a need exists for a large, four-arm randomized controlled trial that includes control, IHG, aerobic, and dynamic resistance training groups that enroll previously sedentary participants with baseline BPs that span the continuum. In addition, studies that examine the BP-lowering effects of different combinations of IHG exercise with aerobic, dynamic resistance training, or both are needed.

Given the observed reductions in resting SBP and DBP as a result of IHG training, it is surprising that this form of training is not promoted to the same degree as aerobic and dynamic resistance training for lowering resting SBP and DBP in adults [41]. One of the possible reasons may have to do with the numerous benefits that can be derived from aerobic and dynamic resistance training [42], whereas the benefits of IHG training may be more limited. Another possible reason may have to do with the limited number of IHG studies when compared with aerobic, and to a lesser extent, dynamic resistance training studies. For example, although only three randomized controlled trials met the inclusion criteria for the current meta-analysis, a total of 72 randomized controlled trials were included in the previously mentioned meta-analysis [9] dealing with the effects of aerobic exercise on resting BP in adults. In addition, nine randomized controlled trials were included for the most recent meta-analysis [11] dealing with the effects of dynamic resistance training on resting SBP and DBP in adults. Still another possible reason may have to do with concerns regarding the acute increases in resting BP associated with isometric exercise. However, these concerns appear to be unwarranted as exemplified by the lack of adverse events in the three studies [20,21,34] included in the current meta-analysis. Finally, a practical concern with IHG exercise may be the cost associated with the instrument itself. However, one [34] of the studies included in the present meta-analysis reported similar reductions in resting BP as the other two studies [20,21] using an inexpensive (∼US $2) spring-loaded IHG device. Thus, cost is probably not a major issue in relation to IHG exercise.

The reductions in resting BP found in the present IHG meta-analysis are also larger than those observed for other lifestyle interventions. For example, a recent meta-analysis [43] of randomized controlled trials examined the effects of various lifestyle interventions on changes in resting SBP and DBP in adults with an average SBP of at least 140 mmHg, DBP of at least 85 mmHg, or both. Reductions in resting SBP/DBP were −4.0/−3.1 mmHg for relaxation therapy, −3.8/−3.2 mmHg for alcohol restriction, and −4.7/−2.5 mmHg for sodium restriction [43]. In contrast, our random-effects IHG results represent reductions that are 2.9–3.5 times greater for resting SBP and 4.2–5.4 times greater for resting DBP.

Given these differences, a need exists for a large, multiple arm, randomized controlled trial that includes a separate IHG group along with other lifestyle intervention groups (relaxation therapy, alcohol restriction, sodium restriction, etc.). In addition, studies that examine the BP-lowering effects of IHG exercise in combination with other lifestyle interventions are needed. Such studies may be particularly timely given the increased interest in comparative effectiveness research.

Although the results of the current meta-analysis are encouraging, the number of studies included was small. Despite the observation that the minimum number of studies required to conduct an aggregate data meta-analysis is two [44] and other published meta-analyses [45–47] have included as few as three studies, caution may be warranted in relation to generalizing the current findings beyond the characteristics of the participants from the studies included in this meta-analysis. Another limitation given the small sample size was the inability to examine potential moderating variables such as age, sex, and medication use. Furthermore, all three studies [20,21,34] assessed resting BP in the laboratory setting using conventional methods. Although recent meta-analytic work [9] has shown that changes in net daytime ambulatory SBP and DBP were reduced to a similar extent as conventional assessment of resting BP, ambulatory monitoring has been shown to be a better predictor of target end-organ damage [48] as well as cardiovascular outcomes in treated patients with hypertension [49]. Given the former, it is suggested that future research include ambulatory BP assessment when examining the effects of IHG training on SBP and DBP.

Although the ability to generalize the findings of this study may be limited given the small sample size, percentile BCIs (5000 iterations) were used to provide a better estimate of the effects of IHG training on resting SBP and DBP. In addition, previous nonrandomized trials have also reported improvements in resting SBP and DBP as a result of IGH exercise. Using hierarchical linear modeling, Millar *et al.* [50] pooled data from three of their previously published studies that included 43 male and female exercise group participants who were medicated for hypertension. After 8 weeks of IHG training, reductions of 5.7 mmHg (4.1%) for resting SBP and 3 mmHg (4.8%) for resting DBP were reported. In another study, McGowan *et al.* [51] examined the effects of 8 weeks of either unilateral or bilateral IHG training in 16 men and women (mean age >60 years) who were medicated for hypertension. Statistically significant reductions of approximately 15 mmHg (11.5%) and 9 mmHg (6.5%) were found, respectively, for resting SBP as a result of bilateral and unilateral IHG exercise. For resting DBP, nonsignificant reductions of approximately 6 mmHg (8.2%) as a result of bilateral training and 4 mmHg (4.5%) as a result of unilateral training were reported. Ray *et al.* [52] examined the effects of 5 weeks of IHG training in 24 healthy, normotensive, untrained men and women 19–35 years of age, assigned to either an IHG exercise, control, or a sham control group. Among exerciser group participants, a statistically significant reduction of 5 mmHg (7.5%) was reported for resting

DBP, whereas a nonsignificant reduction of 3 mmHg (2.6%) was reported for resting SBP. No statistically significant changes in resting BP were reported for either of the control groups. Finally, Peters *et al.* [37] examined the effects of IHG exercise in 10 prehypertensive and hypertensive men and women with a mean age of 52 years. After 6 weeks of training, a statistically significant reduction of 13 mmHg (9.7%) was reported for resting SBP, whereas a nonsignificant reduction of 2 mmHg (2.3%) was reported for resting DBP. Thus, although all of the aforementioned studies reported reductions in resting SBP and DBP as a result of IHG exercise, some results were not statistically significant. One possible explanation for the lack of statistical significance may have to do with the small sample sizes and subsequent low power associated with such.

Although our findings support the efficacy of IHG training for reducing resting SBP and DBP in adult humans, future randomized controlled trials on this topic need to establish the effectiveness of this potential BP-lowering intervention using intention-to-treat-analysis. Future studies should also include complete information on dropouts. This includes the number of participants that dropped out of each group as well as the reasons for dropping out. Furthermore, complete data on compliance to the IHG training intervention (percentage of sessions completed) should be provided. Finally, all assessments should be conducted by individuals who are blinded to group assignment.

In conclusion, the results of this aggregate data meta-analysis suggest that IHG exercise is efficacious for reducing resting SBP and DBP. However, the generalizability of these findings is limited given the small number of studies included.

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There are no conflicts of interest.

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