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Isometric Handgrip as an Adjunct for Blood Pressure Control: a Primer for Clinicians

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Abstract Considered a global health crisis by the World Health Organization, hypertension (HTN) is the leading risk factor for death and disability. The majority of treated patients do not attain evidence-based clinical targets, which increases the risk of potentially fatal complications. HTN is the most common chronic condition seen in primary care; thus, implementing therapies that lower and maintain BP to within-target ranges is of tremendous public health importance. Isometric handgrip (IHG) training is a simple intervention endorsed by the American Heart Association as a potential adjuvant BP-lowering treatment. With larger reductions noted in HTN patients, IHG training may be especially beneficial for those who (a) have difficulties continuing or increasing drug-based treatment; (b) are unable to attain BP control despite optimal treatment; (c) have pre-HTN or low-risk stage I mild HTN; and (d) wish to avoid medications or have less pill burden. IHG training is not routinely prescribed in clinical practice. To shift this paradigm, we focus on (1) the challenges of current HTN management strategies; (2) the effect of IHG training; (3) IHG prescription; (4) characterizing the population for whom it works best; (5) clinical relevance; and (6) important next steps to foster broader implementation by clinical practitioners.

Keywords Hypertension · High blood pressure · Alternative treatments · Clinical practice · Isometric handgrip training

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Introduction

Hypertension (HTN), defined as a systolic blood pressure (BP) ≥140 mmHg and/or a diastolic BP ≥90 mmHg, is a global epidemic [1]. It is the leading cause of cardiovascular disease (CVD) and related mortality worldwide [2–4••, 5], and is responsible for ~10 million deaths each year [6], making it a substantial contributor to global chronic disease burden [7, 8].

HTN is now the most commonly diagnosed condition in primary care [9–11], yet between 50 and 70% of patients are not controlled to within clinical target ranges [12–16••, 17, 18]. In the USA, approximately 34% of adults have HTN [4••], with African Americans, and particularly African American women, having among the highest rates of HTN in the world [2, 4••]. Approximately 14% of American patients have true "resistant HTN" [4••], which is a failure to effectively reduce BP to recommended levels despite compliance to optimal (e.g., three to five anti-HTN medications, one being a thiazide or thiazide-like diuretic) treatment [19].

Uncontrolled HTN is associated with a number of sequelae that are damaging to the cardiovascular system [20–29]. Long-term and potentially fatal blood pressure-related complications include coronary artery disease, heart failure, stroke, and renal failure, in addition to cognitive decline [1,

30–33] and overall poor quality of life [34]. A recent call suggests increasing efforts to lower BP in individuals with resting BP in the pre-HTN (120–139 mmHg) and upper normotensive (110–119 mmHg) range to reduce the global HTN burden [7]. However, while HTN prevention and treatment are global health priorities for the World Health Organization [35, 36], there is a lack of consensus on if and when antihypertensive therapy should be used in those with pre-HTN, making potential non-pharmaceutical alternatives appealing from a public health perspective.

The Challenges of Current Hypertension Management Strategies

The objective of HTN-related clinical practice, in general, is to achieve a resting BP of ≤140/90 mmHg [10, 12, 37–42] using traditional office-based oscillometric measurements, or ≤135/85 mmHg using newer, unattended automated office BP measurement devices [38•, 43]. However, these guidelines are always evolving and will likely become more stringent by lowering BP goals in the near future, at least for higher-risk patients [7, 10]. Adherence to anti-HTN medication, a modified diet (e.g., sodium and alcohol reduction, Dietary Approaches to Stop Hypertension (DASH) eating plan), and increased physical activity are frontline components of BP management [44, 45]. With respect to the latter, international guidelines overwhelmingly recommend aerobic exercise training with dynamic resistance training as an adjuvant intervention [38•, 44–47••].

Despite the existence of these well-publicized management guidelines, non-compliance is common. Less than 50% of patients adequately adhere to their HTN medication regimen [48, 49] for a myriad of reasons including sociocultural and economic considerations, and risk for non-compliance is particularly high in African Americans [50]. Further, adherence to dietary strategies is remarkably poor [47••], and almost half of American adults are inactive (with even higher rates of inactivity reported among African Americans and those living in poverty) [51]. Common barriers to exercise include physical and other health limitations, lack of convenience, competing priorities, and access difficulties [52–54]; these may extend to include an absence of social support, inflexible work schedules, unattainable costs, and unsafe exercise environments [55–58].

In light of the above-noted realities, it is imperative to acknowledge that long-term compliance with traditional BP-lowering treatments is poor [47••]. Thus, complementary treatments that can successfully reduce and maintain BP to within clinical targets are urgently needed, particularly for those that have a high potential for uptake and continuation over long periods of time.

Alternative Hypertension Treatments: Use of Isometric Handgrip Training as a Non-pharmacological Approach to Blood Pressure Management

A plethora of "alternative," non-pharmacological complementary approaches to BP lowering have been investigated over the years, and have been implemented in patient cohorts ranging from pre- to resistant HTN [47••]. Falling broadly into three main categories, these alternative approaches include behavioral strategies (e.g., meditation, biofeedback), non-invasive procedures or devices (e.g., device-guided slow breathing, acupuncture), and novel exercise-based interventions (e.g., isometric handgrip (IHG) training) [47••]. In their scientific statement on alternative approaches to lowering blood pressure, the American Heart Association (AHA) supported the use of biofeedback techniques, device-guided breathing, and IHG training as potentially effective BP-lowering adjuvant therapies, and amenable for use in clinical practice [47••]. For the purposes of this report, we focus our attention on IHG training.

The weight of the evidence suggests that IHG training, a form of isometric resistance training composed of multiple sustained forearm contractions separated by short rest periods, is a safe, simple, and easily adoptable intervention to lower BP. The most recent meta-analysis of randomized controlled isometric resistance training trials (RCTs; $N = 302$) cites post-training reductions in resting BP of ~5/4 mmHg (office and automated), with larger reductions noted in HTN patients [59••]. Early evidence suggests that ambulatory BP, a superior measure for diagnostic and prognostic purposes [60–63], may also be reduced. In the only trials involving ambulatory BP measurement, statistically significant reductions in mean 24-h systolic BP of ~4 mmHg were observed in young healthy adults following IHG training [64], while a clinically relevant post-training reduction was noted in a population of well-controlled HTN patients [65].

The time-efficient IHG protocol lasts as little as 12 min (11 if you discount the last minute of rest), and has proven effective in individuals with and without HTN (even in medicated hypertensives) and those who are already physically active [65–84]. Importantly, IHG training is well-tolerated by participants, and seems to present low levels of risk to safety. High compliance rates have been reported across isometric resistance training trials, and there have been no published reports of acute or long-term adverse events [59••, 80•]. While some clinicians may be concerned about the potential safety of IHG, current data supports only modest transient on-exercise increases in heart rate (Δ 3–8 bpm) and BP (Δ 12–38/7–23 mmHg) for most people studied thus far, even in those with pre-HTN and HTN [74, 80•, 85–88••]. Acute HR and BP changes are less than those elicited during moderate and vigorous aerobic exercise [88••]. However, resistant

hypertensives with more severe HTN (>160–180/100–110 mmHg) may need to exert some caution because of the possible acute BP elevations during IHG, until its safety is established in this group. This is consistent with existing precautionary recommendations regarding the avoidance of aerobic exercise among these patients.

Plausible BP-lowering mechanisms supported by prior trials include improved neural cardiac control (e.g., heart rate variability [71, 73]), augmented arterial compliance and vascular function [68, 80•, 85], reduced sympathetic outflow [73], and/or an enhanced oxidative capacity [82].

Isometric Handgrip Training Prescription

The most common isometric resistance training protocol consists of four, 2-min periods of sustained isometric exercise, separated by brief 1-min rest periods, performed three to five times per week for up to 10 weeks on a handgrip dynamometer. Historically, training sessions have been conducted in laboratory settings, or via a combination of in-laboratory and at-home training. Recently completed pilot work from our group provides evidence, using a randomized single-blind study in HTN patients, that IHG training is feasible and effective when home-based training is prescribed to them by their clinician. IHG training trials have employed handgrip dynamometers ranging from computerized programmable devices to spring-loaded investigator-calibrated handgrips, with the most widely studied to date in HTN patients being the former [59••, 80•]. As the computerized devices are expensive, the financial burden of which may hinder patient uptake, a host of studies are being conducted to investigate cheaper and more readily available alternatives (e.g., stress ball, mechanical handgrips).

While the literature on the effectiveness of IHG training is still accumulating, handgrip resistance training was mentioned in the 2016 Canadian Hypertension Education Program guidelines, and as noted above, IHG training was featured in the AHA Scientific Statement as a potentially viable BP-lowering option [38•, 47••]. In their Statement, the AHA provided an "Algorithm for implementing alternative approaches in clinical practice" which can be applied to IHG training prescription in clinical practice (Fig. 1).

For Which Patients Does It Work Best?

As with most BP-lowering treatments, IHG training appears to be particularly effective in those with higher initial resting BP [67, 70, 81]. In patients with HTN, data suggest that higher initial systolic BP elicits greater post-IHG training reductions [67, 81]. Older individuals, and those with high pre-training systolic BP reactivity to cardiovascular stress tasks (e.g., serial subtraction task, 2-min IHG task), also appear highly responsive to IHG training [67, 70, 77, 89, 90]. African Americans exhibit higher BP reactivity than other populations [91], and

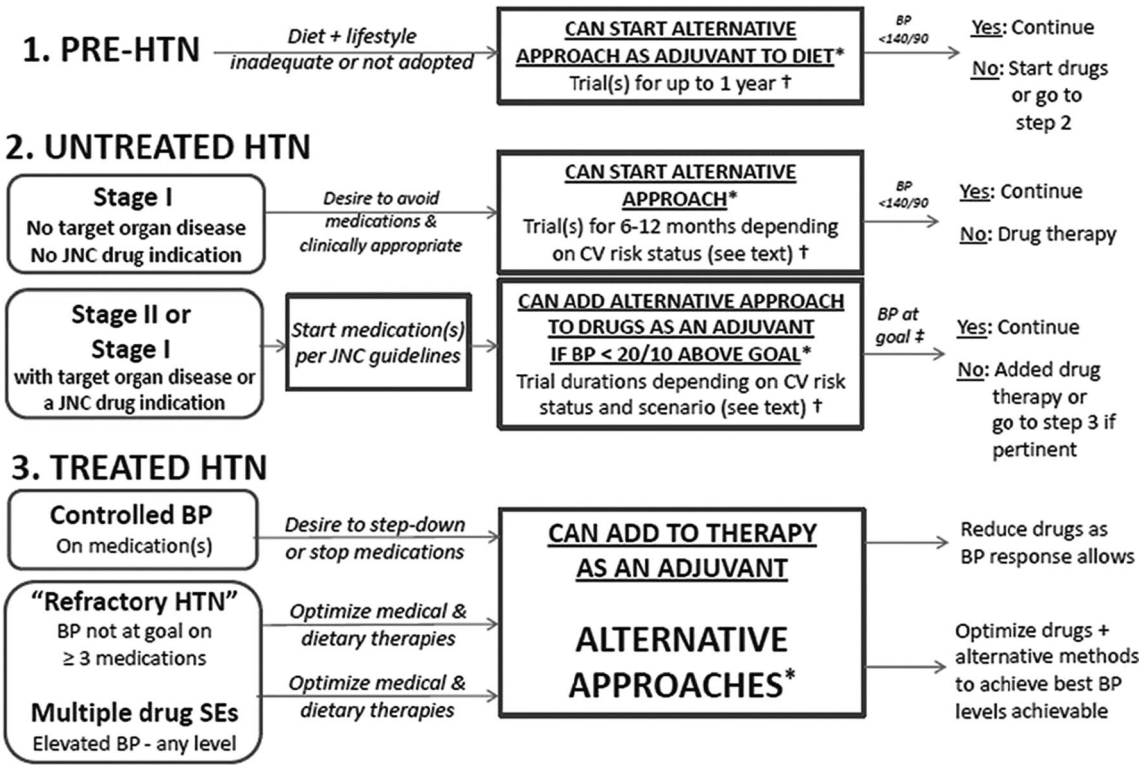

Fig. 1 Algorithm for implementing alternative approaches in clinical practice [47••]. Reprinted with permission from Wolters Kluwer Health, Inc.

thus, IHG training may be particularly beneficial in this patient population. Data focused specifically on this population group, however, is lacking. The effect of gender is also unclear [59••, 64, 70] and may simply reflect the small overall number of women that have participated in IHG training trials to date.

Clinical Significance

IHG training involves the use of a portable hand-held device, is of low time burden, is highly tolerable, and requires no "refills" or other active maintenance efforts. Thus, this treatment is likely to be as attractive to HTN patients as it has been to research participants. From a provider perspective, prescribing an effective intervention that is safe, and one to which patients have a great likelihood to comply, is also enticing. With larger post-training reductions noted in HTN patients, IHG training may be especially beneficial for patients who (a) have difficulties continuing or increasing drug-based treatment care; (b) are unable to attain BP control despite optimal treatment; (c) have pre-HTN or low-risk stage I mild-HTN; and (d) who wish to avoid medications or have less antihypertensive pill burden.

Taken together, this simple treatment has strong potential to impact patient care and improve the rates of BP control among those with HTN. It is important to acknowledge, however, that a post-IHG training reduction of ~5/4 mmHg may not be enough to lower BP to within recommended targets (or within ~10 mmHg of target) for some patients. In these individuals, IHG training may be more appropriate as part of a broader lifestyle approach, with the effects of IHG training adding to the effects of other lifestyle modifications. The effectiveness of this type of multi-modal intervention trial would need to be explored in future IHG training trials.

Despite its promise, IHG training is not routinely prescribed in clinical practice as a BP-lowering management strategy. This critical gap may be due to the limited available data to date; however, it may also be indicative of clinicians being unaware of IHG training or how to prescribe it, a lack of confidence in the ability of the patients to train at home, uncertainty about how to purchase the training devices, and concern relating to the associated cost. The aim of this report is to take the first steps towards addressing this gap, in an effort to shift this paradigm.

Important Next Steps

In their 2017 Heart Disease and Stroke Statistics Update, the AHA stated that "the elimination of HTN is projected to have a larger impact on CVD mortality than the elimination of all other risk factors among females, and all except smoking among males" [4••]. It is our over-arching goal to improve BP control and reduce the burden of HTN by incorporating IHG training as part of a comprehensive treatment strategy in clinical practice. Most IHG training studies to date have been small, short-duration, proof-of-concept trials. Large-scale, high-quality RCTs of longer duration are urgently needed to address these earlier limitations and further establish the merits of this effective treatment. Future work should aim to explore the potential additive effects of IHG training to traditional lifestyle modifications (e.g., DASH diet, aerobic exercise training), medical practice, and home-based effectiveness models of IHG training, including trials in patients with resistant HTN and pre-HTN/mild-HTN wishing to avoid medication. Moreover, trials investigating the long-term persistence of BP lowering, training interventions using less expensive handgrip devices, and those evaluating population-specific BP-lowering mechanisms, patient and physician burden, clinical outcomes, and economic benefit are also needed.

Conclusion

Poor BP control puts many Americans and individuals around the world at risk for serious and often fatal complications of HTN. African Americans are disproportionately affected as are all individuals with treatment-resistant HTN. There is an urgent need to translate effective BP-lowering therapies, such as IHG training, into standard care that act alone or as an adjunct to traditional treatments. By increasing the proportion of patients achieving BP control, we take an important step towards reducing the burden of HTN in our country and beyond.

Compliance with Ethical Standards

Conflict of Interest The authors declare no conflicts of interest relevant to this manuscript.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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- • Of importance
- •• Of major importance

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