MITIGATING HYPERTENSION RISK IN COLLEGE-AGED BLACK AND WHITE WOMEN USING ISOMETRIC HANDGRIP TRAINING: A RANDOMIZED CONTROL TRIAL

by

Grayden E. Beaufort

A thesis submitted to the faculty of
The University of North Carolina at Charlotte
in partial fulfillment of the requirements
for the degree of Master of Science
in Kinesiology

Charlotte

2023

Approved By:

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Dr. Reuben Howden

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Dr. Jeanette Bennett

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Dr. Luke Donovan

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Dr. Wendy Holliday

ABSTRACT

GRAYDEN E. BEAUFORT. Mitigating Hypertension Risk in College-Aged Black and White Women: A Randomized Control Trial

(Under the direction of DR. REUBEN HOWDEN)

Hypertension is the most prevalent risk factor for future development of cardiovascular disease, the leading cause of death worldwide. Isometric exercise training (IET) has been shown to decrease blood pressure and resting heart rate in certain populations, but its impact on young (18-25 years) women is not well understood. Further, black women may especially benefit from IET due to several factors including healthcare discrimination, psychosocial factors, and worse cardiovascular health profiles compared to white women of the same age. Eleven young white and black women were selected to participate in either eight weeks of IET using a handgrip dynamometer (n = 5) or eight weeks of a non-intervention control protocol (n = 6). Baseline measurements of resting systolic blood pressure, diastolic blood pressure, and resting heart rate were compared to post-intervention levels. Analysis of this data showed an average change in systolic blood pressure (0.04 ± 9.37), diastolic blood pressure (2.21 ± 6.5), and resting heart rate (-6.12 ± 10.73) for the control group. The handgrip IET group showed an average change in systolic blood pressure (0.75 ± 8.36), diastolic blood pressure (0.75 ± 6.3), and resting heart rate (-0.48 ± 6.63). No statistically significant differences were found between baseline and post-intervention for any of the response variables.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Cardiovascular disease (CVD) has been the leading cause of death in the United States and worldwide for the past 80 years [45, 46]. This includes several conditions such as stroke, peripheral artery disease, congestive heart failure, and ischemic and coronary heart diseases. One in every four deaths is caused by CVD in the United States while globally, CVD accounts for 32% of all deaths. CVD risk and development are largely impacted by several behavioral and lifestyle habits. Smoking, unhealthy use of alcohol, regular consumption of unhealthy foods, physical inactivity, and obesity are among the most prevalent behavioral and lifestyle choices which impact CVD development and risk. Cessation of harmful behaviors and the establishment of healthy habits is usually recommended as the first line of defense against the early development of CVD and is widely regarded as an effective preventive strategy to preserve cardiovascular health [18]. However, it is important to understand that CVD risk does not impact everyone equally. Several factors including day-to-day stress, heredity, aging, and socioeconomic factors also play in CVD risk. Further, mortality associated with CVD is highest among women, accounting for 1 in 3 deaths worldwide, and people of African descent, regardless of sex, education, or socioeconomic status [2].

High blood pressure (HBP) or hypertension, represents a major risk factor for the development of several cardiovascular diseases and it affects nearly half of all adults in the United States. Due to its asymptomatic nature, hypertension has been dubbed the ‘silent killer’ as half of the adults living with the condition are completely unaware. For this reason, it is critically important for all adults to have their blood pressure measured regularly. On a worldwide scale, hypertension is estimated to affect 1.13 billion people and is on track to increase by 15-20% by 2025 [22], which is a major public health concern. The risk of developing or unknowingly living with hypertension increases through the lifespan affecting 33.2% of all adults aged 40-59 and 63.1% of all adults aged 60 and over [24]. Several chronic conditions are associated with hypertension including chronic kidney disease, diabetes mellitus, and obesity - all of which further the risk of developing a chronic cardiovascular illness. Of those that are aware of their high blood pressure, only 1 in 4 have it under control [20]. Current standard interventions for high blood pressure management include pharmacological interventions, dietary modifications, and regular resistance and aerobic-based exercise. Poor adherence to these recommendations has been observed by the World Health Organization (WHO) especially regarding pharmacological interventions due to a lack of resources to fill prescriptions, unwanted medication side effects and not taking medications as prescribed [27]. Since hypertension generally produces no symptoms, convincing people to take medications that make them experience side effects presents a unique psychological challenge to blood pressure management [26]. Irregular administration of anti-hypertensive medications has been shown to cause ‘rebound hypertension’, where blood pressure levels remain elevated or even increase, regardless of the presence of the anti-hypertensive drug. This is a relatively common phenomenon observed in anti-hypertensive medications that involve sympathetic nervous system inhibition such as beta-blockers or alpha agonists [19]. Exercise recommendations are also poorly adhered to due to a lack of access to facilities, lack of time to commit to exercise, and lack of knowledge or experience with exercise. For those affected by hypertension who are also new to regular exercise, social support and proper education concerning specific exercise recommendations is critically important as fear of exercise-induced injury, comfortability, and lack of motivation can easily present additional barriers to exercise adherence. It is incredibly important for our global society to understand how to effectively control hypertension as successful BP lowering has been shown to decrease the risk of stroke by 36%, heart failure by 43%, coronary heart disease by 16%, and all-cause mortality by 11% [23].

It has long been reported that minorities experience higher rates of hypertension compared to whites [2,4]. Specifically, black Americans suffer the highest rates of hypertension across all age, race, and socioeconomic categories. The purpose of this study is to focus on hypertension prevalence and treatment between college-aged black women and white women. Black women are disproportionately affected by hypertension compared to their white counterparts. 58% of black women in the United States suffer from high blood pressure compared to a rate of 41% in white women [25]. Further, young black women are 2.4 times more likely to suffer from hypertension compared to white women despite lower rates of recreational drinking, smoking, and oral contraceptive use - all of which are known factors to increase the risk of developing hypertension [3]. The most widely accepted reason for this discrepancy is the significant difference in stress experienced by black women compared to women of other ethnic groups on a day-to-day basis [8,28]. To combat this discrepancy, interventions for high-risk groups, such as black women, must focus on reducing stress while promoting the safety, efficiency, and simplicity of the intervention.

Isometric exercise training (IET) exhibits a high potential for success in blood pressure management. This level of intervention requires minimal equipment, time, and experience to perform. Scientific data regarding IET as an intervention for blood pressure management is sparse, however, the studies that do exist have shown success in lowering both diastolic and systolic blood pressure readings in short-term trials. Investigators involved in these trials continue to push the need for further studies to strengthen the body of evidence regarding IET as an alternative exercise intervention for high blood pressure.

Isometric exercise training (IET) is a unique form of exercise in which muscular force is exerted against a fixed resistance without changing the length of the muscle or muscle group involved, once steady state force is reached. Examples of common isometric exercises are known as wall-sits, static planks, glute bridges, or deadhangs. This study focused on isometric handgrip training which involves the use of the hand and forearm musculature to statically hold a level of resistance within one's grip for a given length of time. This is advantageous as a mode of exercise since there is a minimal range of motion, very little equipment is required, and can be completed in any practical location. The hypotensive effects of isometric exercise training were first reported by Kiveloff and Huber in 1971 after having hypertensive subjects perform maximal isometric handgrip contractions for 6 seconds, 3 times a day for up to 8 weeks. Since then, researchers have experimented with the specific variables of isometric handgrip training (level of resistance, duration, frequency, etc.) to determine the most effective IET regimen to elicit a favorable hypotensive response.

Uncontrolled hypertension is the single largest contributor to the development of various cardiovascular diseases and a major contributor to the development of kidney disease. In 2010, high blood pressure cemented itself as the leading risk factor for the global burden of disease [29]. Despite the manageability and awareness our society has of hypertension, we have not found a reliable way to control this condition. As rates of high blood pressure continue to rise in our country, so do the costs of treatment. The Centers for Disease Control and Prevention (CDC) estimates that hypertension costs the United States $131 to $198 billion each year, which is expected to rise as prevalence of hypertension continues to increase [30]. By advising patients to treat their high blood pressure with simple, cost-effective, and efficient interventions such as IET, we can lower the astronomical burden hypertension places on our global society, allocate resources towards medical advancements, and help others to live a higher quality of life.

LITERATURE REVIEW

Hypertension affects nearly half of all adults in the United States and represents the most important risk factor in the development of cardiovascular diseases including stroke, myocardial infarction, coronary heart disease, and ischemic heart disease [20, 29]. Hypertension is especially associated with stroke, which is the second leading cause of mortality and the third leading cause of disability worldwide [34]. This represents an astronomical public health crisis as personal health costs associated with stroke alone are estimated to be $70,000 and $24,000 for inpatient and outpatient rehabilitation respectively [35]. The Centers for Disease Control and Prevention (CDC) estimates hypertension to cost the United States up to $198 billion every year in health care services, medications, and loss of productivity due to premature death. However, this number does not reflect the costs of non-fatal illnesses associated with high blood pressure, implying the actual costs of hypertension to be much greater [30]. Perhaps more striking than its estimated costs and risks is the ability to prevent hypertension. Taking steps to limit stress, healthy dietary choices, physical activity, and limiting certain lifestyle choices such as smoking and alcohol consumption are all widely recommended behaviors used to decrease the probability of developing hypertension and ultimately, cardiovascular disease.

Despite widespread information and awareness on how to control hypertension, society’s ability to control hypertension is still very much a work in progress. Of all adults aware of their hypertension, only 1 in 4 have their condition under control, despite widespread education on lifestyle decisions to benefit cardiovascular health [20].

Prescription medications for hypertensives present their own unique set of challenges in their ability to control hypertension. These medications include alpha inhibitors, angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, beta-blockers, calcium channel blockers, central alpha agonists, diuretics, and renin inhibitors. Common side effects reported when using these medications include fatigue, headache, depressed mood, constipation, diarrhea, erectile dysfunction, frequent urination, and difficulty sleeping [43]. Kretchy et. al. found that the presence of these side effects significantly impacts rates of adherence to various prescription medications and was furthered by social factors, media influences, and attitudes of primary care providers [26]. Sporadic adherence to antihypertensive medications can cause a condition known as rebound hypertension, in which blood pressure rises even further in response to self-halting or lowering the dose of a prescribed medication. This is a very common condition for sympathetic nervous system inhibitors such as beta blockers or alpha agonists [19]. Van der Wardt et. al. estimates only 1 in 4 hypertensives can successfully withdraw from antihypertensive medications without their elevated blood pressure returning for 2 or more years, with the highest chance of success being in patients taking only 1 medication [47]. This phenomenon suggests the body forms a dependency on these drugs to manage blood pressure, furthering the costs and allocation of resources towards filling and producing these prescriptions as demand increases. While rebound hypertension is most severe in patients taking beta blockers and alpha agonists, other medications have been shown to exhibit rebound hypertension, though not as drastic. In patients taking ACE inhibitors, a rapid rise in blood pressure back to baseline levels immediately following drug cessation was reported [36]. As ACE-inhibitors and beta-blockers represent 48% of prescribed antihypertensive meds, these findings further indicate that a large portion of prescription medications only provide short-term solutions to the problem, rather than addressing the root cause to control hypertension without regular drug use [37].

Certain groups can be affected by hypertension more than others. Cardiovascular disease is responsible for 1 in every 3 deaths in women, compared to a rate of 1 in every 4 deaths in men [1,38]. Despite fundamental physiological differences between men and women, many decisions regarding the management of CVD in women are based on research completed with male subjects [1]. Even disparities regarding success rates of controlling hypertension with prescription medications have been noticed between men and women. Women have significantly higher rates of antihypertensive drug use compared to men (61.4 % vs 56.8% respectively), yet only 44.8% of women achieve BP control vs 51.1% of treated men [6]. Black women are especially vulnerable to hypertension, as they have the highest prevalence of hypertension of any race or gender group at 41.5% [39]. Further, this is a condition that develops much earlier in the lifespan for black women compared to other ethnic groups. A review by Mensah et. al. sought to better understand health disparities centered around cardiovascular diseases based on several national surveys which included both self-reported and measured data [2]. The results show that young (>/= 18 years) black women have a higher prevalence of obesity, large waist circumference (> 88cm), and hypertension compared to their white and hispanic counterparts of the same age. The only groups with higher levels of obesity and hypertension than young black women were black women over the age of 18. Another review by Hines et. al. used NHANES data to determine young (18-35 years) black women were 2.4 times more likely to be affected by hypertension despite lower rates of smoking, drinking, or use of oral contraceptives compared to white women of the same age [3]. However, young black women were found to have a lower prevalence of high (≥ 130 mg/dL) LDL cholesterol and triglycerides (≥ 150 mg/dL) compared to white and hispanic women of the same age. This is especially concerning given the fact that black women give birth at an average age of 24 years and studies have shown hypertension through pregnancy is associated with low birth weight, a major predictor and risk factor for future cardiovascular disease [5, 40]. In this sense, hypertension prevalence in young black women is a realized, systematic generational problem that puts children at a huge physiological disadvantage before they are even born.

The etiology for a higher prevalence of hypertension in black women is not well understood, but the most widely accepted hypothesis for this disparity is higher levels of psychosocial stress [8]. While stress is not known to directly cause hypertension, research shows that chronic stress has a major influence on the development of hypertension through repeated bouts of blood pressure spikes and the vasoconstricting action of various stress-related hormones [41, 7]. Risk factors for the development of chronic stress are globalization, workplace related stress, emotional distress, discrimination, socioeconomic changes and related challenges, and social environments. One study by Sternthal et. al. analyzed psychosocial stress on health outcomes by race [8]. The types of stress included the prevalence of individual day-to-day stressors and measures of severity for various stress classifications. Health outcomes were assessed using self-reported indicators of physical and mental health status. The results show that black Americans have the highest level of cumulative stress, as well as the worst health profiles in every category except the self-reported health 5-point scale. Further, black participants reported the highest number of individual stressors, and were determined to have the highest level of overall stress based on statistical analysis. Relationships between stress levels and health profiles were statistically consistent across all racial groups which include whites, blacks, American-born hispanics, and foreign-born Hispanics.

Considering the literature and statistics within the domain of hypertension prevalence and racial disparities, alternative modes of blood pressure management must be determined and adopted to curb this public health crisis. Despite widespread efforts to control hypertension through lifestyle modification and antihypertensive medications, only 26.1% of American hypertensives achieve blood pressure control (<130/80 mmHg) [20]. Of those that have achieved blood pressure control using medications, their level of control must be maintained by indefinitely adhering to their medication to avoid the risk of rebound hypertension and other side effects.

Isometric exercise training (IET) represents a promising alternative method in blood pressure management. This promising intervention strategy requires very little equipment, time, or a certain fitness level to complete while lessening an individual's reliance on pharmacological interventions and drastic lifestyle changes. Convenience represents another attractive feature of IET, as this can be performed while watching TV (for example) and meditation requires as little as 5 minutes of focused time to complete.

A systematic review by Cornelissen et. al. analyzed the effect of several modes of regular exercise training to determine the most effective for blood pressure control. Out of 93 studies involving endurance, dynamic resistance, combined, and isometric resistance training, reductions in SBP and DBP were larger in isometric resistance studies compared to all other modes of exercise [9]. This indicates an advantage isometric training has over other forms of exercise for blood pressure management, yet hypertensives are typically recommended by care providers to engage in daily endurance and/or dynamic resistance exercise training according to recommendations from large organizations such as the American College of Sports Medicine (ACSM) [42]. In the Cornelissen review, only 5 out of the 93 analyzed studies involved IET, while the rest studied endurance, resistance, or combined training. This realization only furthers the need for more research centered around IET and cardiovascular health, as the prevalence of hypertension continues to rise and adherence to traditional exercise interventions remains low.

Studies involving hypotensive responses when utilizing handgrip IET have largely focused on determining the most effective parameters (time, intensity, frequency, muscle group) of the regimen to lower blood pressure. Since Kiveloff and Huber's trial from 1971 when maximal effort handgrip training presented a decrease in blood pressure [44], researchers have experimented with different intensities, population groups, and frequencies to develop the most effective form of IET to lower blood pressure. Of all the variables to be altered within an IET regimen, researchers have most commonly used 30% maximal voluntary contraction (MVC) regardless of population, frequency, and muscle group involved [15, 16, 17]. A randomized control trial by Carlson et. al. compared a 30% maximal voluntary contraction (MVC) group to a 5% MVC "sham" group performing handgrip IET for 8 weeks [17]. The purpose of the 5% MVC "sham" group was to test the efficacy of using an insignificant handgrip IET protocol for the control group as opposed to a sedentary control group. At the end of the protocol, the 30% MVC group presented a significant reduction in systolic blood pressure (7-mmHg) and mean arterial pressure (4-mmHg) while the 5% MVC "sham" group presented an insignificant reduction in systolic blood pressure (2-mmHg) and mean arterial pressure (3-mmHg). No significant reductions in diastolic blood pressure were observed in either group. These results indicate a clinically significant reduction in resting blood pressure can be achieved at an intensity level as low as 30% MVC, while a reduction, although insignificant, can still be observed at an intensity of 5% MVC. This has promising implications, as those who find 30% MVC to be uncomfortable could begin their intervention at a much lower intensity level and gradually increase the intensity over time, while still making improvements in resting blood pressure levels.

Another randomized control trial explored the effectiveness of handgrip IET at 30% MVC on a 400-person cohort of unmedicated pre-hypertensive (SBP rage 120-139 mmHg, DBP rage 80-89 mmHg) men and women between the ages of 30 and 50. 200 participants were allocated to the 30% MVC isometric training group with lifestyle modification while the remaining 200 were allocated to the control group, which was assigned lifestyle modification only. Unlike many other trials involving any form of IET, subjects allocated to the training group performed 24 consecutive days of handgrip training consisting of 2, two-minute handgrip contractions separated by a 5-minute rest period. Both groups experienced statistically significant reductions in both diastolic and systolic blood pressure, however the reduction was higher in the IET group. SBP reductions were 7.47 ± 1.69 mmHg for the exercise group and 4.07 ± 2.61 mmHg for the control group. DBP reductions were 6.42 ± 1.01 mmHg for the exercise group and 3.89 ± 1.62 mmHg for the control group. The results from this study show that lifestyle modification is effective in lowering blood pressure if adherence is consistently maintained, but can be enhanced by just 9 minutes per day of handgrip training [16].

IET has been demonstrated to be effective in lowering blood pressure when training other muscle groups as well. A randomized control trial by Gill et. al. involving a double-leg IET program with one group performing at 20% EMGpeak (~23% MVC) and another at 30% EMGpeak (~34% MVC) saw young (21-27 years) participants present with significant blood pressure reductions in as little as 3 weeks. Significant reductions in both systolic and diastolic blood pressure (-3.6 ± 1.03 mmHg and -4 ± 0.99 mmHg, respectively) were observed in the 30% EMGpeak group, but not the 20% EMGpeak group or control group, suggesting that the threshold for hypotensive responses to IET exist between 23% MVC and 34% MVC. Interestingly, when comparing the extent of reduction in systolic blood pressure between male and female participants, it was observed that female participants were able to decrease systolic blood pressure by an average of -6.9 mmHg while males were only able to achieve an average decrease of -1.5 mmHg. While there were no statistically significant differences between male and female participants when grouped by their assigned intensity regimens, these findings could suggest that younger women may be more sensitive to the hypotensive responses to IET. The results of this study also imply reductions in blood pressure measures may take place within a shorter timeframe when larger muscle groups are subjected to the IET regimen. Further research is needed to confirm both of these possibilities.

Double-leg IET has also been explored in older (45-60 years) men and was shown to be effective in lowering resting systolic and mean arterial blood pressure. This study utilized specific electromyography (EMG) values for each participant that equated to 85% of their heart rate maximum to determine each participant's training intensity. The training intensity equivalent to 85% of each participant's maximal heart rate was interpolated from the linear relationship between heart rate and EMG generated during an initial incremental exercise test. Significant reductions in systolic blood pressure and mean arterial pressure (11 ± 8 mmHg and -5 mmHg, respectively) were noticed in the training group while the control group levels remained unchanged. Further, a significant reduction in resting heart rate (-5 bpm) was also observed in the training group. No significant changes in diastolic blood pressure were observed in either group.

The researchers performing this study chose to test the effectiveness of double-leg IET in older men as similar hypotensive responses had been previously noted by Wiles et. al. in a younger (18-34 years) male population performing a similar protocol [33]. In the study with younger male subjects, 2 groups performing IET at 2 different intensities (~21% MVC and ~10% MVC) both had resting systolic, diastolic, and mean arterial blood pressure reduced after completing an 8-week IET program. The findings from this study, along with the results from the Gill trial indicate younger populations may be more susceptible to decreases in diastolic blood pressure from performing IET compared to older populations, as both studies involving younger populations were able to achieve statistically significant decreases in diastolic blood pressure while studies involving older subjects were not. These findings are especially encouraging for young women as they may be more susceptible to the hypotensive adaptations in both systolic and diastolic blood pressure measurements in response to IET.

METHODS

Main Study:

The data used in this thesis is part of a much larger study currently being conducted at the University of North Carolina – Charlotte between the Department of Psychological Sciences and the Department of Applied Physiology, Health, and Clinical Sciences. The main study includes three groups: a control group, a handgrip training group, and a meditation/ breathwork training group. All groups complete surveys three times per week in addition to their training which measures various psychosocial factors. The control group only completes these surveys as their weekly requirements to participate in this study as there is no training program for them to perform. All psychological aspects of the study are not a part of this thesis, which focuses on the physiological variables as relevant to the authors' course of study.

Thesis Methods:

Participants were recruited from The University of North Carolina at Charlotte community and deemed eligible if they were cisgender females who identify as either black or white and were between ages 18-25 years. Those interested in participating contacted the research team via phone or email in response to campus-wide recruitment emails and were asked to complete a simple eligibility screener using a Qualtrics survey link. The screener ensured all potential participants met eligibility criteria and were able to participate in the study safely. After eligibility confirmation by the screener each participant was asked to visit the on-campus lab space to gather baseline blood pressure and heart rate measurements. Participants were asked to refrain from caffeine 12 hours before this visit, avoid all food and drink 2 hours prior, avoid strenuous activity for 24 hours prior, and pass urine before the baseline visit. The research team completed a verbal checklist at the beginning of the visit to ensure all pre-measure instructions had been followed. Participants signed the informed consent document before any data collection took place. Subjects sat alone in the laboratory room for a 15-minute "rest" period to ensure the accuracy of resting blood pressure and heart rate recordings. During this time, participants were instructed to place a Polar V800 band and wear link under their shirt and across their chest to record heart rate variability throughout the rest period. Following the rest period, resting blood pressure and heart rate values were recorded for each participant and the data were stored in a secure, locked cabinet to which only the lead investigator and a single member of the research team had access to.

Participants were randomized and allocated to one of two groups - the control group (no intervention) or the handgrip isometric exercise training (HG) group. Randomization was completed using a block random number generator with consideration for race to ensure all three groups have similar or equal numbers of black and white females.

Eligible and consenting participants were invited to the Health Risk Assessment Lab at their convenience within the first 2 weeks of the protocol for a Dual-Energy X-ray Absorptiometry (DEXA) scan. There was no expectation that any group's body composition would change throughout the timeframe of the interventions; however, upper body lean mass could influence the efficacy of the isometric handgrip protocol. The GE Lunar device (GE Lunar Primo Prodigy, Madison, WI, USA; enCORETM 2011 software version 15) was used to measure bone mineral content (BMC), body fat percentage (BFP), and total fat-free mass (FFM) via total body and regional DEXA scans. Subjects were allowed to wear normal clothing but were asked to remove any accessories or articles of clothing containing metal as this could impact the accuracy of the DEXA scan. Subjects were instructed to lie motionless in a supine position while a mechanical arm emitting X-rays slowly scanned body surface area. This scan typically takes 15 minutes and poses no threat to the participants. All personnel administering DEXA scans on participants have completed relevant equipment and x-ray safety training under the direction of the Health Risk Assessment Coordinator and were wearing a visible radiation badge. DEXA is considered the gold-standard for total body composition analysis as it provides accurate measurements on all relevant body composition measures.

The majority of the 8-week protocol was completed by subjects at a location of their choosing. The handgrip training protocol was facilitated online via 3, weekly Qualtrics surveys with embedded components to guide participants through their intervention. Participants allocated to the isometric exercise training (IET) group (n = 5) were provided with a handgrip dynamometer during the baseline visit and required to measure their maximal voluntary contraction (MVC). Instructions on how to measure and recalculate MVC was provided each week as part of the

Qualtrics surveys used for the intervention. Participants allocated to the HG group followed the protocol of 4, 2-minute contractions at 30% MVC three times a week for 8 weeks. Each contraction was performed using the dominant hand and was subsequently followed by a 1-minute rest period. 30% MVC was calculated by the participants at the beginning of each week by following the recorded instructions available via Qualtrics surveys. This allowed participants to stay at a constant level of 30% MVC, even if strength adaptations occurred throughout the 8-week protocol.

The control group (n = 6) simply followed their normal routine for 8 weeks but was asked to complete 3 weekly "check-ins" via Qualtrics surveys measuring the same mood and psychosocial variables as the HG group. It is important to note that the weekly survey components measuring psychosocial variables across all groups changed weekly, however, none of the data are included in this thesis. These measures included discrimination reactivity, gratitude, emotional reactivity, sleep quality, loneliness, optimism, and depression. For example, the week 1 survey could've included a component which asks all groups about the quality of their sleep while the following week's surveys could've asked participants about their feelings of loneliness. Regardless, every participant in every group was assessed on the same psychosocial measures each week after completing their assigned protocol.

The post-treatment visit was largely identical to the baseline visit, however there was no consent, fewer questionnaires, and a $75 Amazon gift card compensation was provided.

DATA ANALYSIS

Differences between baseline (V1) and post-intervention (V2) measurements of resting heart rate, and systolic and diastolic blood pressure were assessed across both groups using a two-way ANOVA test with an alpha level set at 0.05. In addition, one-way ANOVA tests were also performed to test for significant differences in each response variable, and baseline descriptive data between both groups at baseline. Due to the low sample size of the data, effect size was calculated using the output of each ANOVA test to gauge potential significant differences if the study was repeated with a larger population. All statistical analysis was completed using RStudio version 4.2.1.

RESULTS

Eleven total participants completed this study. Six participants were allocated to the control group, while 5 participants were allocated to the handgrip training group. Descriptive data gathered by the DEXA scans are available in Table 1 showing the mean and standard deviation for each descriptor by group. No statistically significant differences were noticed between either group for each descriptive category. Results from the one-way ANOVA tests comparing group differences in the response variables at baseline showed no significant differences between groups. Table 2 provides a full breakdown of these analyses including effect size (Eta squared) values.

Results from the two-way ANOVA tests showed no significant differences over time in any of the response variables (systolic blood pressure, diastolic blood pressure, resting heart rate) between either group. Although there were no significant changes, relatively large F values produced by the ANOVA calculations for systolic blood pressure and resting heart rate indicated there is a trend towards significance that could be observed in a similar study with a larger sample size. Due to this, an effect size calculation was performed using the ANOVA data for each response variable. A full breakdown of this data is available in Table 3. While insignificant, differences were noticed in systolic blood pressure (0.04 ± 9.37), diastolic blood pressure (2.21 ± 6.5), and resting heart rate (-6.12 ± 10.73) for the control group. Additionally, the handgrip IET group showed insignificant differences in systolic blood pressure (0.75 ± 8.36), diastolic blood pressure (0.75 ± 6.3), and resting heart rate (-0.48 ± 6.63). These changes are depicted in Figures 1a, 1b, and 1c, respectively.

TABLE 1: Descriptive data by group.

	Control (n = 6)	**HG Training (n = 5)**
Age (yrs.)	21.27 ± 1.92	22.72 ± 2.06
Height (cm.)	161.93 ± 9.83	163.58 ± 8.15
Weight (kg.)	72.39 ± 19.57	57.53 ± 13.50
Body Fat Percentage	36.52 ± 5.94	31.72 ± 8.97
Lean Mass (kg.)	43.39 ± 9.67	36.65 ± 4.29
Fat Mass (kg.)	26.12 ± 10.54	18.39 ± 9.35
Bone Mineral Content (kg.)	2.45 ± 0.63	2.19 ± 0.14
Fat-Free Mass (kg.)	45.86 ± 10.25	38.82 ± 4.40
Grip Strength (kg)	29.25 ± 5.04	26.0 ± 10.28

TABLE 2: Response variable differences at baseline by group.

	Mean ± SD Control	**Mean ± SD HG Training**	**F-value**	**P-value**	**Eta^2**
Systolic BP	115.83 ± 7.82	119.9 ± 8.95	0.66	0.44	0.07
Diastolic BP	75.78 ± 4.53	74.73 ± 5.09	0.13	0.73	0.01
Resting Heart Rate	81.21 ± 8.76	77.07 ± 8.23	0.65	0.44	0.07

TABLE 3: Response variable differences between baseline (V1) and post-intervention (V2) by group.

	Mean ± SD Control (V1)	Mean ± SD HG Training (V1)	Mean ± SD Control (V2)	Mean ± SD HG Training (V2)	F-value	P-value	Eta^2
Systolic BP	115.83 ± 7.82	119.9 ± 8.95	115.79 ± 9.27	119.18 ± 8.16	1.04	0.32	0.05
Diastolic BP	75.78 ± 4.53	74.73 ± 5.09	73.57 ± 7.09	73.98 ± 4.30	0.018	0.89	0.001
Resting Heart Rate	81.21 ± 8.76	77.07 ± 8.23	87.35 ± 12.81	77.60 ± 8.14	2.74	0.12	0.13

FIGURE 1a: Delta Systolic Blood Pressure.

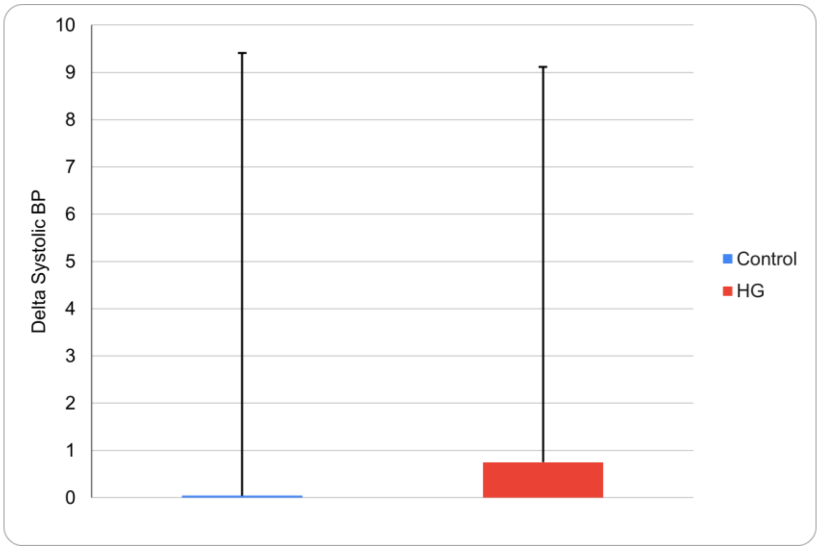


FIGURE 1b: Delta Diastolic Blood Pressure.

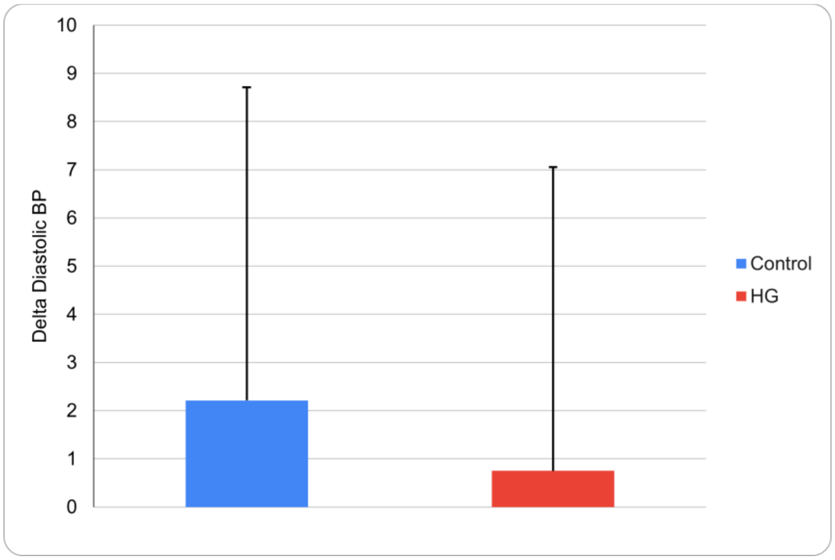
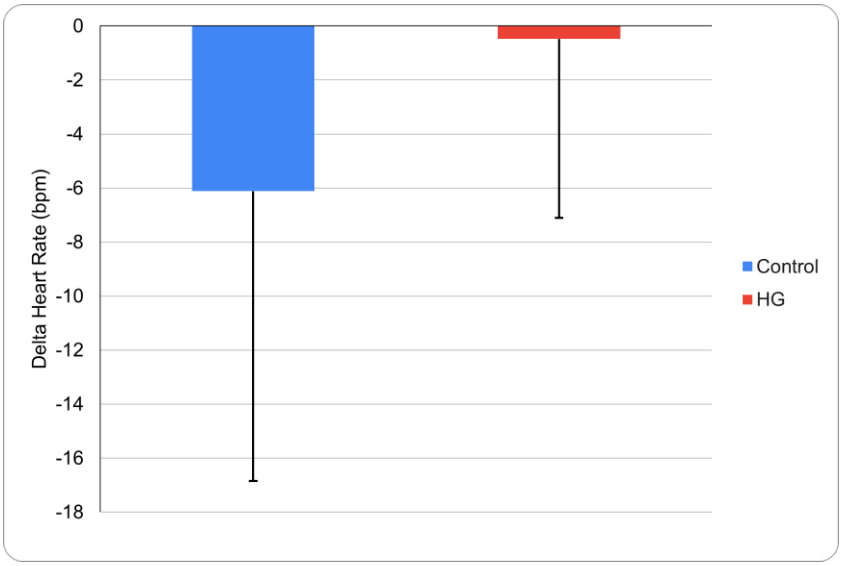


FIGURE 1c: Delta Resting Heart Rate.



DISCUSSION

Although not statistically significant, baseline descriptive data gathered from participants of the present study showed a wide range of differences between groups in weight (Control = 159.6 ± 43.14, HG = 126.84 ± 29.77), lean mass (Control = 95.65 ± 21.32, HG = 80.8 ± 9.45) and fat mass (Control = 57.59 ± 23.24, HG = 40.54 ± 20.62). While these differences didn't make a significant impact on the outcomes of this study, it is possible similar differences could make an impact on results in future studies with a larger study population. For this reason, future studies could find it beneficial to have participants undergo a DEXA scan before they are randomized and placed into a study group, or have general descriptive data such as BMI factored into the randomization process.

Post-intervention data analysis showed no significant changes in systolic blood pressure, diastolic blood pressure or resting heart rate between either group, which isn't surprising with such a small study population. However, further analysis revealed an F-value of 1.04, P-value of 0.32, and effect size of 0.05 when considering the differences in systolic blood pressure. This indicates that with a larger study population, significant differences could be observed in systolic blood pressure post-intervention. A recent meta-analysis showed that in any study where participants are only performing IET ≥ 3 weeks, regardless of limb group, statistically significant reductions in systolic blood pressure had an 89% chance of observation [64]. This analysis by Kelley et. al. also maintained statistically significant measures of heterogeneity and consistency between the trials included by measure of The Grading of Recommendations Assessment, Development and Evaluation (GRADE) instrument. A meta-analysis by Inder et. al. observed an average decrease in systolic blood pressure of 5.2 mm Hg in subjects performing IET, however this response was even larger (7.2 mm Hg) in subjects performing IET ≥ 8 weeks [58].
Perhaps even more encouraging was the F-value of 2.74, P-value of 0.12, and effect size of 0.13 associated with the change in resting heart rate. This indicates a higher trend towards significance in resting heart rate differences, a variable seldomly observed to be statistically affected by IET [9]. On the other hand, the F-value (0.018), P-value (0.89), and effect size (0.001) associated with diastolic blood pressure changes revealed no potential for significant differences post-intervention. This is not surprising, as diastolic blood pressure is a variable

shown to be inconsistently affected by IET, with a 52% chance of eliciting a clinically significant response [64]. While these numbers are encouraging, future studies with a larger study population must be conducted in order to explore any potentially significant outcomes in any of the relevant response variables.

The original study plan incorporated several psychological factors such as self-reported psychosocial measures, heart rate variability measures, and a training group which participated in 8 weeks of meditation and breathwork exercises. These factors were removed from this thesis to prioritize the physiological aspects of isometric handgrip training and its impact on resting blood pressure and heart rate. While participation outlook for this study looked promising during early recruitment, it is important to recognize the profound rates of attrition experienced by the research team throughout the data collection period. In total, 221 women applied to participate, 96 passed the eligibility screener, 49 were scheduled for an in-person lab visit and completed the consent process, and 11 completed all aspects of the study protocol (after removing those who were placed in the meditation and breathwork training group). These attrition rates are depicted in Figure 2. This is likely the most impactful reason for why the analysis was severely underpowered and no associations between the handgrip training and any of the response variables were noticed. Further, it was our intention to compare responses to the two training protocols by race as well, but with the exceptional attrition rates it made very little sense to further split our analysis pool. Despite this shortcoming, this study did implement a practical method to remotely monitor adherence to IET at home, which has been identified as a major area for improvement in advancing the literature on this topic [48, 61]. In utilizing the Qualtrics platform to administer each training session, the research team was able to track weekly training activity and ensure participants were accurately performing the training by providing instructions to recalculate 30% handgrip MVC each week without participants having to return to the lab for supervised training sessions.

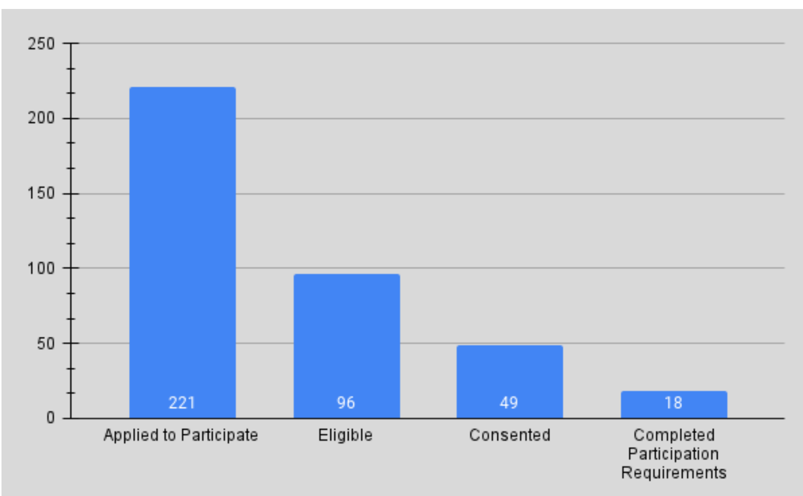
Heart rate variability (HRV) measures were gathered during the pre and post intervention lab visits but were ultimately removed from this thesis to prioritize the relationship between IET, blood pressure, and resting heart rate. Further, HRV data was gathered from participants while they performed the 15-minute rest period and the 5-minute paced breathing task during both laboratory visits, but not while performing handgrip MVC. R-R interval measured by the Polar V800 band and wear link was used to gather HRV data. HRV has been identified as a variable closely related to psychological stress via changes in autonomic nervous system activity, particularly due to parasympathetic withdrawal [65]. This closely ties into the relationship between the brain and the heart, as autonomic cardiac function is tightly regulated by parasympathetic (PNS) and sympathetic (SNS) nervous systems [66]. Dysfunction in the autonomous functions of the cardiovascular system is characterized by an imbalance between PNS and SNS activity via increased peripheral SNS stimulation and decreased vagal tone, both of which have important implications for hypertensives [67, 68]. Paced breathing exercises have been shown to increase parasympathetic control of the heart and improve HRV, thereby regulating cardiac function [69]. For this reason, the main study aimed to investigate if the meditation and breathwork training group would see improvements in their response variables via improved HRV, especially in a more stress-vulnerable population such as black women. While HRV has been adopted by psychological researchers, it remains a physiological measurement closely related to resting heart rate. Both heart rate variability and resting heart rate are valuable predictive factors for cardiovascular disease and adverse events [70, 71]. Resting heart rate represents a significant risk factor for cardiovascular mortality while HRV provides insights to changes in autonomic functioning [72, 73]. As heart rate closely influences HRV in both a mathematical and physiological way, a recent meta-analysis has concluded the impact improvements in resting heart rate has on HRV makes HRV a better predictor for cardiovascular outcomes [74]. This is especially encouraging when interpreting the results of the present study, as the strong trend towards a significant improvement in resting heart rate suggests IET could have a major influence on HRV and therefore autonomic function and cardiovascular outcomes. To provide further insight on how IET influences HRV, future studies could include an additional sample of HRV data from participants while they complete a trial of the IET training protocol during the pre and post intervention laboratory visits.

The purpose of this study was to investigate alternative methods of blood pressure management in normotensive black or white women aged 18-25. Blood pressure control is crucial in women, as hypertension is associated with higher rates of left ventricular hypertrophy in older women compared to men [49]. It is also important for women to achieve blood pressure control early in life as premenopausal elevation in systolic blood pressure has been identified as a significant risk factor for coronary atherosclerosis [50]. Black women represent a population that is especially at risk for the dangers of hypertension as they suffer higher rates of hypertension, lower rates of blood pressure control, and earlier onset of elevated blood pressure compared to women of other ethnic groups [51, 52]. Action taken to prevent hypertension early in life, especially in particularly vulnerable populations like black women, is perhaps the greatest preventive measure available to mitigate the development of hypertension [53]. IET is a simple, convenient, and cost-effective method for most people to improve their cardiovascular health, and has been shown to be effective in lowering blood pressure and improving cardiovascular health markers in women [54, 55, 57]. Additionally, performing IET at home is advantageous over other exercise forms, as at-home training improves patient empowerment and adherence to physical activity in those managing chronic illnesses like hypertension [56]. Performing handgrip IET three days per week at 30% MVC, 4 x 2 minutes is considered the most effective intensity and frequency range according to the current literature [58]. Badrov et. al. also found no significant differences between performing IET at this intensity 3 days per week versus 5 days per week in normotensive women [55]. Thus, the participants of the present study were prescribed the most effective, time-efficient, and convenient IET protocol throughout their 8 weeks of participation. Past studies involving IET and young women demonstrate a hypotensive response in systolic blood pressure but not diastolic blood pressure or resting heart rate after 8 weeks of training [54, 55, 57]. Mechanisms for this hypotensive response is not well understood but may be due to cardiac autonomic modulation or enhanced antioxidant protection [59, 60]. Very few studies have investigated the effect IET has on black women, and those that did explored acute variables such as muscle pain during exercise and blood pressure responses immediately following IET [62, 63]. In order to advance the body of knowledge on this topic, more studies must be conducted on the effects of 8 weeks of IET training in black women.

CONCLUSION

This study demonstrated a simple way to monitor adherence to at-home IET, which is an important factor in the adoption of this convenient intervention to manage blood pressure. Further, this study added to the growing body of knowledge surrounding IET and its interactions with blood pressure by focusing on a study population of young black and white women. Additional strategies to decrease attrition rates should be implemented in future studies such as spacing out compensation throughout the training period, or periodically meeting with the participants throughout the training period to ensure they are still active in their training protocol. Few studies have investigated interactions between black women and IET. This is a significant area for exploration in the topic of hypotensive responses to IET and could have several public health implications for one of the most at-risk populations for cardiovascular illness.

FIGURE 2: Attrition rates.



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