

**UTILIZING EXERCISE AND HEAT THERAPY TO  
IMPROVE BLOOD PRESSURE**

**Honors Thesis**

**Presented in Partial Fulfillment of the Requirements  
For the Degree of Bachelor of Science in Sport and Movement Science**

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## Table of Contents

Acknowledgements.....	ii
Abstract.....	iii
Introduction/Background.....	1
Methodology.....	3
Results.....	7
Discussion.....	10
Conclusion.....	11
References.....	13

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## **ABSTRACT**

Nearly half of U.S. adults suffer from some form of cardiovascular disease. Previous research has shown that exercise is an essential lifestyle intervention to improve cardiovascular health and heat therapy, in forms of hot baths or saunas, may provide numerous cardiovascular health benefits. The purpose of this research was to investigate how the combination of exercise and heat therapy impacted ambulatory blood pressure, compared with heat therapy or exercise alone. The study consisted of three trials in a randomized, counterbalanced order in which each subject partook in all three treatments: exercise alone, heat alone, and the combination being exercise followed with heat therapy. Each exercise trial consisted of treadmill walking for 30 minutes at 60% effort. Each heat therapy trial consisted of 45 minutes in a hot (42C) leg bath. The combination session consisted of the exercise trial followed by a heat therapy trial. Following each session, subjects ambulatory blood pressure and heart rate variability was taken overnight to assess the outcomes that the interventions had on the subjects. Exercise alone had no change in systolic pressure with the average night blood pressure across all subjects was 117 mmHg and the post-trial blood pressure average was 118 mmHg. Exercise alone did lower diastolic blood pressure by 3 mmHg from 67 mmHg to 64 mmHg. Heat alone lowered systolic blood pressure from 117mmHg to 113 mmHg showing a 4mmHg difference. Heat alone also lowered diastolic blood pressure by 4mmHg from 67mmHg to 63mmHg. It was found that the combination of exercise and heat therapy had no change in systolic blood pressure, but the largest impact was on diastolic blood pressure lowering it by 8mmHg.



## **INTRODUCTION / BACKGROUND**

Hypertension is defined as having high blood pressure. In the US alone, hypertension affects nearly one hundred and sixteen million people. Worldwide, hypertension affects 1.39 billion people. Blood pressure can then be divided into systolic blood pressure and diastolic blood pressure. Systolic blood pressure measures the amount of pressure being exerted on the arterial walls during a heartbeat, while diastolic blood pressure measures the amount of pressure being exerted on the arterial walls in between heartbeats. When diagnosing hypertension in patients, lifestyle changes, like exercise are recommended. This is because exercise has reliably shown to reduce blood pressure in patients with an elevated risk of cardiovascular disease, like hypertension (Fargard et, al. 2007). Alongside exercise, newer research has shown that heat therapy (repeated passive heat exposure) can reduce resting blood pressure (Brunt et, al. 2016) (Ely et, al. 2019). Heat therapy can take many forms, including leg immersion, full body immersion, or sauna use.

It is important to know how much blood pressure can decrease after a single bout of exercise when compared to chronic exercise training. To be a meaningful decrease in blood pressure, trials must reduce systolic/diastolic blood pressure by a 3-mmHg difference (FDA, 2007). When looking at blood pressure in comparison to single bouts of exercise and chronic exercise training, previous research can reliably show that both lower blood pressure, but which one will have the most meaningful impact? Previous studies have shown the following:

Forty-minute sessions, three times per week for sixteen weeks at an average intensity of 65% of heart rate reserve resulted in a reduction in SBP of 6.9 mm Hg and in DBP of 4.9

mm Hg. (Fargard, et al. 2007). Walking for a mean of nineteen weeks four point four days a week for thirty-six point five minutes a day resulted in a mean reduction in SBP of 5.2 to 11.0 mmHg and in DPB of 3.8 to 7.7 mm. (Lee et, al. 2010). Moderate aerobic exercise in the form of jogging at a consistency of three to five times a week, for four to fifty-two weeks, thirty to sixty minutes per session can show a reduction in SBP of 3.5 mmHg and in DBP a reduction of 2.5 mmHg (Cornellissen et, al. 2013). Single bouts of exercise also affect ambulatory blood pressure and reductions in systolic and diastolic blood pressure have been seen. After single bouts of exercise, ambulatory blood pressure has been seen to dip overnight, but not enough to conclude meaningful impacts, showing a decrease of 1.94mmHg -2.7 mmHg. (Machado et, al. 2021). This shows it has potential to be helpful but cannot be defined as a meaningful impact.

Investigating the effect that trials have on ambulatory blood pressure is important because when looking at overnight blood pressure, ambulatory blood pressure dipping found from data has shown a relationship to cardiovascular risk and disease prognosis (Cardoso et, al. 2010). Therefore, this study aimed to investigate the impact of acute exercise, heat exposure, or combined exercise and heat exposure on overnight blood pressure, hypothesizing that the largest decrease of blood pressure will come from the combination of exercise and heat therapy trials.

Therefore, this study aimed to investigate the impact of acute exercise, heat exposure, or combined exercise and heat exposure on overnight blood pressure, hypothesizing that the largest decrease of blood pressure will come from the combination of exercise and heat therapy trials.

## **METHODOLOGY**

### Procedure:

This randomized, counter balanced repeated measured design, meaning the order of trial was always completely randomly and every subject has completed all three trials over the course of three weeks. All trials were separated by a minimum of four days. The exercise trial, subjects underwent an exercise treatment as well as a sham water treatment (34 degrees Celsius). The heat trial, subjects will undergo a heat treatment with the water set to 42 degrees Celsius. The combination trial of both exercises followed by heat, consists of an exercise treatment along with a heat treatment with the water set to 42 degrees Celsius.

### Description of the testing session:

#### Exercise Trial:

Upon arrival, the subject had their height, weight, age, and age collected. The subject was then fitted for the equipment. The subject then spent fifteen minutes sitting in a chair to take baseline measures of heart rate, tympanic temperature, and blood pressure. After the fifteen minutes were completed, the subject would begin their 30 minutes on the treadmill starting at a 2% grade and a 2.5 mph speed. The speed and grade were then adjusted to meet their 60% heart rate maximum reserve. Every five minutes, heart rate, speed and grade were assessed. Once the subject completed thirty minutes, their tympanic temperature was taken, and their

total distance completed on the treadmill was noted. After completing the treadmill, the subject was fitted with equipment to begin the sham heat trial. Using a leg bath with water set to 34 degrees Celsius, the subject placed their legs in, with their calves and below immersed in water. Every five minutes for forty-five minutes, tympanic temperature, heart rate, blood pressure, thermal comfort and thermal sensation measurements were taken. Thermal sensation and thermal comfort were assessed on a Likert scale. After the sham trial was done, the subject was sent home to wear the Welch Allyn Ambulatory Blood Pressure Cuff and monitor and Bio strap wrist monitor overnight.

#### Heat Trial:

Upon arrival, the subject would have had their height, weight, age, and age collected. The subject would then be fitted for equipment. The subject would then spend fifteen minutes sitting in a chair to take baseline measures of heart rate, tympanic temperature, and blood pressure. After the fifteen minutes were completed, the subject would begin the heat trial. Using a leg bath with water set to 42 degrees Celsius, the subject placed their legs in, with their calves and below immersed in water. Every five minutes for forty-five minutes, tympanic temperature, heart rate, blood pressure, thermal comfort and thermal sensation measurements were taken. Thermal sensation and thermal comfort were assessed on a Likert scale. After the sham trial was done, the subject was sent home to wear the

Welch Allyn Ambulatory Blood Pressure Cuff and monitor and Bio strap wrist monitor overnight.

Exercise & Heat Trial:

Upon arrival, the subject would have had their height, weight, age, and age collected. The subject was then fitted for equipment. The subject would then spend fifteen minutes sitting in a chair to take baseline measures of heart rate, tympanic temperature, and blood pressure. After the fifteen minutes were completed, the subject began their 30 minutes on the treadmill starting at a 2% grade and a 2.5 mph speed. The speed and grade were then adjusted to meet their 60% heart rate maximum reserve. Every five minutes, heart rate, speed and grade were assessed. Once the subject completed thirty minutes, their tympanic temperature was taken, and their total distance completed on the treadmill was noted. After completing the treadmill, the subject was then fitted with equipment to begin the heat trial. Using a leg bath with water set to 42 degrees Celsius, the subject placed their legs in, with their calves and below immersed in water. Every five minutes for forty-five minutes, tympanic temperature, heart rate, blood pressure, thermal comfort and thermal sensation measurements were taken. Thermal sensation and thermal comfort were assessed on a Likert scale. After the sham trial was done, the subject was sent home to wear the Welch Allyn Ambulatory Blood Pressure Cuff and monitor and Bio strap wrist monitor overnight.

### Measurements:

Every trial started with taking the subjects age, weight, and height. During exercise and exercise and heat therapy trials, tympanic temperature was measure at the beginning of the treadmill walking and post treadmill walking, while taking heart rate, and note of the grade and speed every five minutes. During all three trials, where water was involved, whether it be heat trial (42 degrees Celsius) or the sham trial (34 degrees Celsius), every five minutes tympanic temperature, heart rate, blood pressure, thermal sensation and thermal comfort were taken. Data taken during trials were precautionary measures for safety. While we did not expect anyone to, this was a way to ensure no subjects had any adverse reactions to the trials. The nights before and after trials, subjects were given a Welch Allyn Ambulatory Blood Pressure Cuff and Monitor to measure blood pressure. Blood pressure was measured every hour, and mean values from 1-3am each night were reported as overnight blood pressure for each subject. The overnight blood pressure values taken for the three pre-trial days were averaged as baseline overnight blood pressure. Subjects also as wore a Biostrap Wrist Monitor to measure Heart Rate Variability which collected date throughout the night to collect the mean resting heart rate as well as heart rate variability for a related study.

### Data Analysis

Values are reported as mean  $\pm$  standard deviation unless otherwise noted. The primary outcome variables for this study were nocturnal systolic and diastolic blood

pressure. Results were analyzed using GraphPad Prism software using a repeated measures (time x treatment) ANOVA design.

## **RESULTS**

### Subject Characteristics:

Data collection shown is six completed subjects (3 female, 3 male), between the ages of 21 to 35. Four out of the six participants had elevated blood pressure while two out of the six subjects were classified as normotensive.

	EX	ExHT	HT
Total Distance (mi)	1.65 ± 0.3	1.65 ± 0.3	N/A
Speed (mi/hr)	3.4 ± 0.5	3.4 ± 0.5	N/A
Grade (%)	3.8 ± 1.2	3.8 ± 1.2	N/A
Mean HR (bpm)	125 ± 11	128 ± 13	89 ± 18

Table 1: The table above shows distance and heart rate measured during exercise trials.

This shows that every trial was organized and run identical to the previous one and that trials stayed consistent throughout subjects.

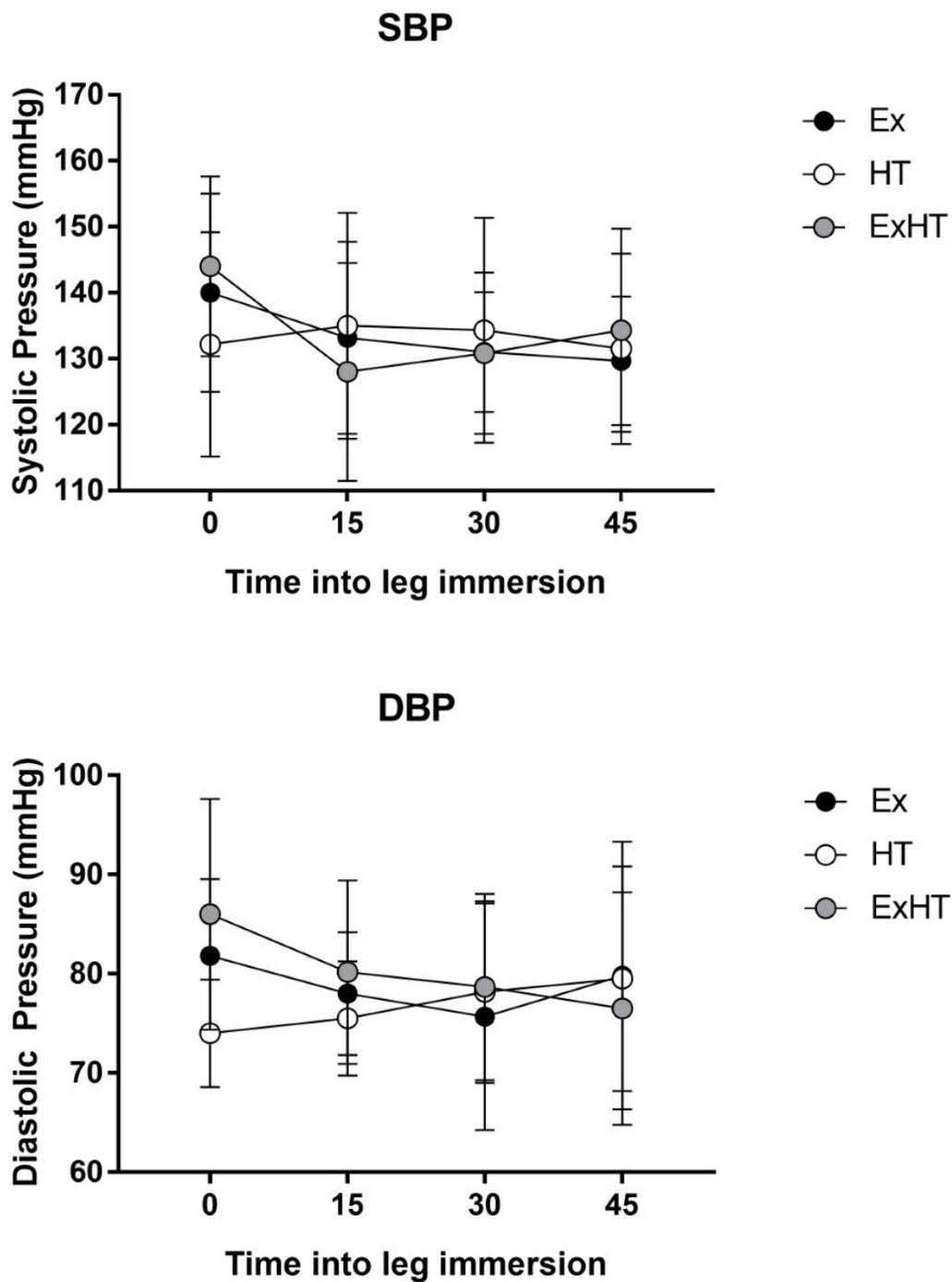


Figure 1: Systolic and Diastolic blood pressure measurements taken during water trials (heat therapy and sham trials) over a forty-five-minute immersion period. These measurements were not factored into ambulatory data, but rather taken as a safety

precaution. Tracking blood pressure during leg immersion allows researchers to confirm the participant does not have any adverse reactions to the trials, which we did not expect any participants to. The largest decrease was found in systolic blood pressure immediately following the exercise and heat therapy combination trial.

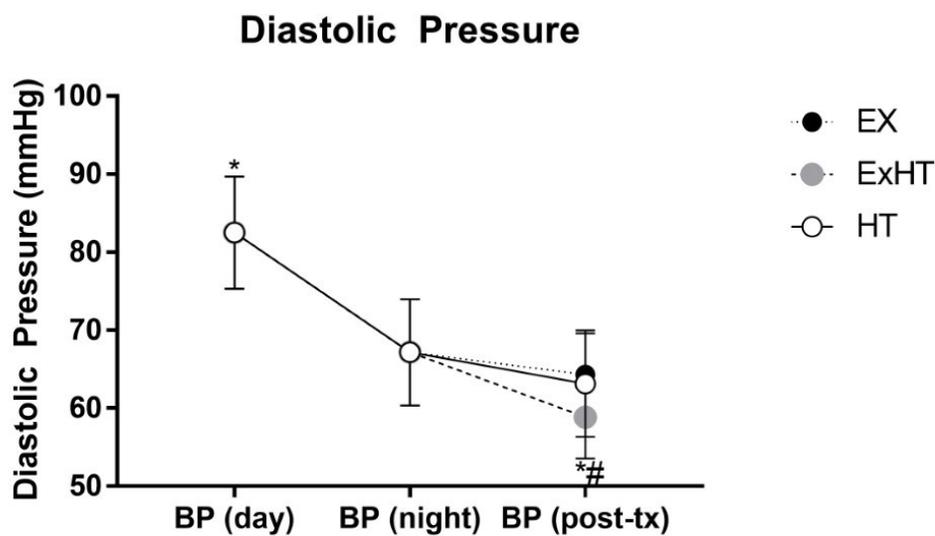
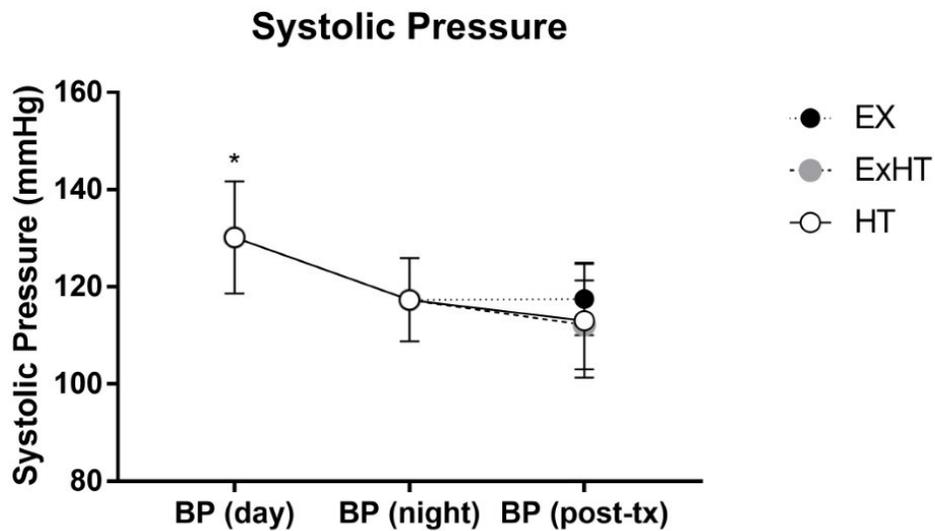


Figure 2: The figure above are blood pressure measurements collected during the previous day and night of trial and the night after trial. During the day, systolic and diastolic blood pressures are at their highest. During the night into post trial are when blood pressures decrease and are found to be the lowest. There was no change seen in systolic blood pressure with any trial. Diastolic blood pressure saw a significant decrease of 5 mmHg after the combination trial of exercise followed by heat therapy. This significant decrease is represented in the asterisk located above the mean BP (day) and BP (post-Tx).

## **DISCUSSION**

Nearly half of U.S. adults suffer from some form of cardiovascular disease. Impaired cardiovascular health can be reflected in having a high blood pressure and reducing blood pressure can be done through exercise or heat therapy, as previously researched. This study found that all three treatments (exercise, heat therapy, exercise, and heat therapy) were well tolerated by all participants. There was no change in systolic blood pressure found in any of the three treatments, but diastolic blood pressure was lower following exercise and heat therapy combination trial. Diastolic blood pressure was lowered 8 mmHg after exercise and heat therapy making it a significant impact, compared to exercise alone and heat therapy alone. This is an important finding because while exercise is recommended for those who have an elevated blood pressure, not enough people are exercising regularly and often enough for it to make a meaningful impact on cardiovascular health.

. When looking at acute exercise, previous research has found a 3.3-3.5mmHg decrease in ambulatory blood pressure (Fagard et, al. 2007). With heat therapy, over a course of eight weeks, a 4mmHg reduction was found in blood pressure which increases cardiovascular related mortality. (Brunt et, al. 2016) Heat therapy has also shown larger decreases in blood pressure. 30 sessions of heat therapy provided a systolic blood pressure decrease of 10 mmHg and diastolic blood pressure saw a decrease of 9 mmHg. (Ely et, al. 2017). A natural occurrence that we saw in blood pressure is nocturnal dipping. Nocturnal dipping is defined as a 10% decrease of blood pressure when at night/ sleeping. (Mayo Clinic, 2021). This study's average systolic day time blood pressure was 130 mmHg and the average systolic ambulatory blood pressure was 117 mmHg seeing a 10% decrease for nocturnal dipping which was as expected. The average diastolic day time blood pressure was 83 mmHg and the average diastolic ambulatory blood pressure was 67 mmHg seeing well more than a 10% decrease for nocturnal dipping.

## **CONCLUSION**

Research supports that exercise followed by heat therapy can help to reduce blood pressure. This is important because being able to lower your blood pressure can reduce your risk of cardiovascular disease and can improve your overall mortality. Our finding of diastolic blood pressure decreasing five mmHg after the combination trial of exercise followed by heat therapy is a significant meaningful finding

This research can open doors to advances in the non-pharmacological treatment of hypertension and elevated blood pressure using a combination of exercise and heat therapy. Both activities are considered affordable and low risk of injury. These treatments

are readily accessible at home or in fitness centers. If more people utilize these options that could lead to a decrease in cardiovascular disease across the world, leading to a healthier population.

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