The Impact Of Exercise And Heat Therapy On Overnight Heart Rate Variability

Honors Thesis

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Abstract

Previous research has shown that exercise is an essential lifestyle intervention to improve cardiovascular health and that heat therapy, in the form of hot baths or saunas, may provide numerous cardiovascular health benefits. **Purpose:** To investigate how combined acute exercise and heat therapy will impact nocturnal heart rate variability, compared to heat therapy or exercise alone in normotensive and hypertensive individuals. We hypothesized that combined exercise and heat therapy will result in a larger decrease in nocturnal heart rate and a larger increase in heart rate variability when compared to heat therapy and exercise tested alone. **Methods:** This study consisted of three trials in a randomized, counterbalanced order in which six subjects [3 male, 3 female, age 24 ± 6 yr, body mass index (BMI) 30 ± 6] participated in three treatments: exercise alone, heat alone, or exercise and heat combined. Each exercise session consisted of walking on a treadmill for 30 minutes at 60% effort. Each heat therapy session consisted of 45 minutes in a hot (42C) leg bath. The combination session consisted of the exercise trial followed by a heat therapy trial. After each session, subjects ambulatory blood pressure and heart rate variability was taken overnight to assess the outcomes that the interventions had on the subjects. **Results:** Overnight heart rate significantly decreased following the HT intervention when compared to Ex, ExHT, and baseline measures (Pre: 76 ± 18; Post: 62 ± 14 beats/min); No treatment significantly altered overnight heart rate variability: Ex (Baseline: 68 ± 36; Post: 72 ± 36 ms), ExHT (Baseline: 68 ± 36; Post: 71 ± 34 ms), and HT (Baseline: 68 ± 36; 66 ± 26 ms). **Conclusion:** Ultimately, exercise alone, heat alone, and exercise and heat combined did not appear to impact the reciprocal balance of sympathetic and parasympathetic dominance assessed by HRV.

I. Introduction/Background

Nearly half of U.S. adults suffer from some form of cardiovascular disease, which can be reflected in high blood pressure and heart rate variability (American Heart Association 2021). Previous research has indicated that autonomic abnormalities and decreased heart rate variability are associated with increased all-cause and cardiovascular mortality (Binici et.al 2011). Heart rate variability is a primary variable for this study used as a measure of autonomic function. Furthermore, heart rate variability (HRV) is the measurement of variation between each heartbeat by assessing the cardiac autonomic nervous system and positive adaptations to exercise. Heart rate, heart rate variability, and blood pressure are controlled by a balance of sympathetic (fight or flight response) and parasympathetic nervous system (rest and digest) activity. The parasympathetic system is responsible for increasing heart rate variability and decreasing heart rate, and blood pressure whereas the sympathetic system is responsible for increasing heart rate, blood pressure, and decreasing heart rate variability. Prior research has displayed that individual's with greater HRV have a decreased risk of cardiovascular disease and mortality as a result of chronic or acute aerobic exercise training (Zabriskie, et.al 2021).

Existing research on the impact of both chronic and acute exercise training and heat exposure has shown that regular aerobic exercise, particularly of high intensity, can significantly increase heart rate variability. While greater heart rate variability can be obtained through chronic training, heart rate variability also responds acutely. In this respect, heart rate variability commonly exhibits a transient decrease after a single bout of exercise (Zabriskie et.al, 2021). The impact of chronic or acute heat exposure on heart rate variability has not been extensively studied. Therefore, the purpose of this study was to investigate the impact of combined acute exercise and heat exposure on heart rate variability since both in combination has not been examined.

II. Methodology

Procedure:

To begin, subjects met with the investigator the day before the first trial to obtain informed consent and were given a BioStrap wrist monitor and ambulatory blood pressure cuff to wear overnight. During this randomized study, the subjects performed three different trials: exercise alone, exercise + heat therapy, and heat alone performed in the Performance Laboratory in the O'Keefe Complex at Salem State University. A randomized, counterbalanced repeated measure design, means that the order of each trial was always completely random, and every subject had to complete 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 underwent a heat treatment with the water set to 42 degrees Celsius. The combination trial of both exercise followed by heat, consisted 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 gender 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 the water mid-calf. 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 BioStrap wrist monitor overnight.

Heat Trial:

Upon arrival, the subject would have had their height, weight, age, and gender 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 subjects placed their legs in the water mid-calf. 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 BioStrap wrist monitor overnight.

Exercise & Heat Trial:

Upon arrival, the subject had their height, weight, age, and gender collected. The subject was then fitted for equipment. The subject would 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 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 the water mid-calf. 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 BioStrap wrist monitor overnight.

Measurements:

Every trial started with taking the subjects height, weight, and age. 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 BioStrap wrist monitor to measure overnight heart rate variability. Overnight heart rate variability was measured every ten minutes, and mean values from 1-3am each night were recorded as overnight heart rate variability for each subject. Overnight resting heart rate values for the first pre-exercise trial days was used to calculate each subject's heart rate reserve. Subjects also wore a Welch Allyn Ambulatory Blood Pressure Cuff to measure blood pressure which collected data throughout the night to collect the mean blood pressure for related research.

Data Analysis:

The primary outcome measures included heart rate and heart rate variability, taken overnight after each treatment. This study employs a repeated-measures design, with each subject serving as their own control. The three treatments will be compared using a two-way (time x treatment) repeated-measures ANOVA, and significant main or interaction effects will be examined using Tukey's post-hoc analysis.

III. <u>Results</u>

Data was collected from six subjects [3 male & 3 female, age 24 ± 6, body mass index (BMI) 30 ± 6, and daytime BP 130 ± 12 / 83 ± 7]. Daytime blood pressure (BP) indicated that four of six subjects had elevated blood pressure at baseline. Each Subject wore the BioStrap wrist monitor the night prior to the protocol and the night following the protocol. The BioStrap wrist monitor measured heart rate (HR) and nocturnal heart rate variability (HRV).

Responses to Exercise:

It was important to demonstrate that each trial remained consistent, and there was no change or deviation among variables. All subjects completed each exercise session that consisted of 30 minutes of treadmill walking and each exercise session was matched by the subjects calculated heart rate reserve (calculated based on resting heart rate measurement taken in the lab and age-predicted maximum heart rate).

	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 average total distance, speed, grade, and heart rate during each exercise session.

Responses to Leg Immersion:

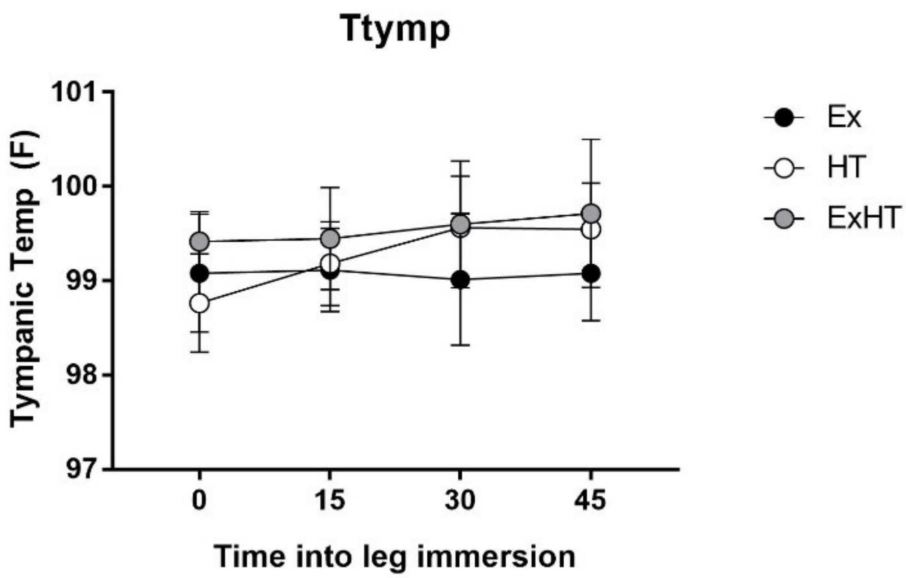

Fig 1: Tympanic temperature (Ttymp) during HT or Sham immersion. Ttymp was measured every five minutes for safety precautions.

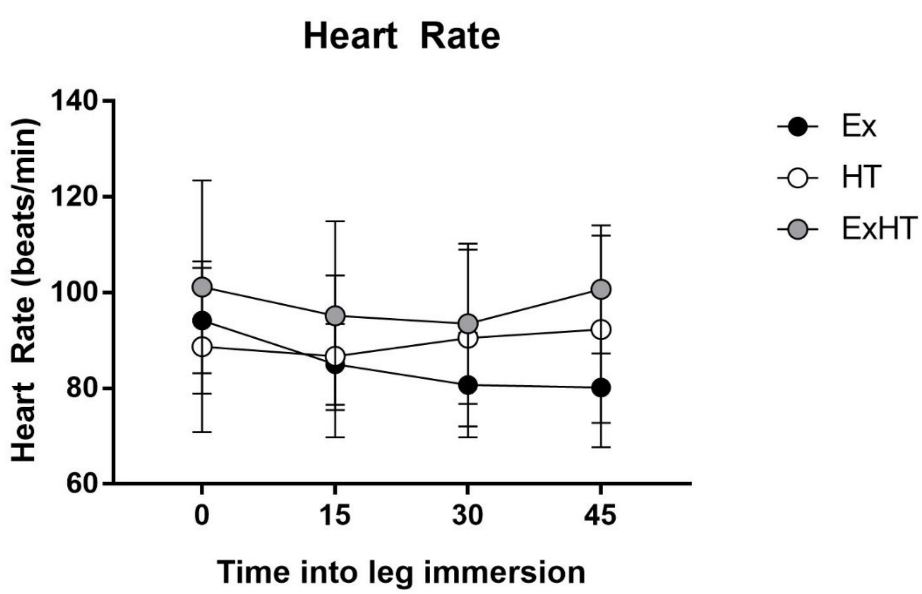

Fig 2: Heart Rate during leg immersion Ex, ExHT, and HT trials.

Overnight HR and HRV:

Nocturnal heart rate decreased following the HT intervention but did not decrease following EX and ExHT interventions; no treatment altered nocturnal heart rate variability, overnight HRV was heterogeneous.

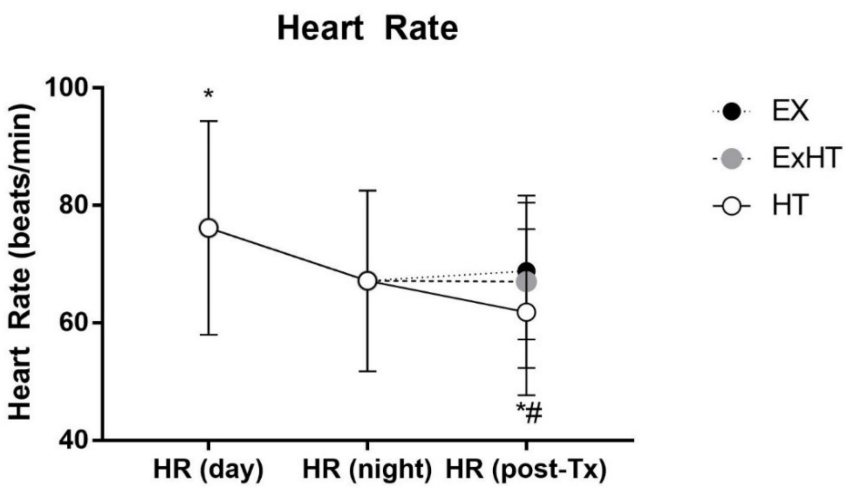

Fig 3: Heart Rate (HR) during the day [HR (day), following no treatment] [baseline; HR (night), Ex, ExHT, and HT [HR (post-Tx)]. The symbol (*#) indicates there was a significant statistical difference in overnight HR followed by HT alone compared to Ex or EXHT.

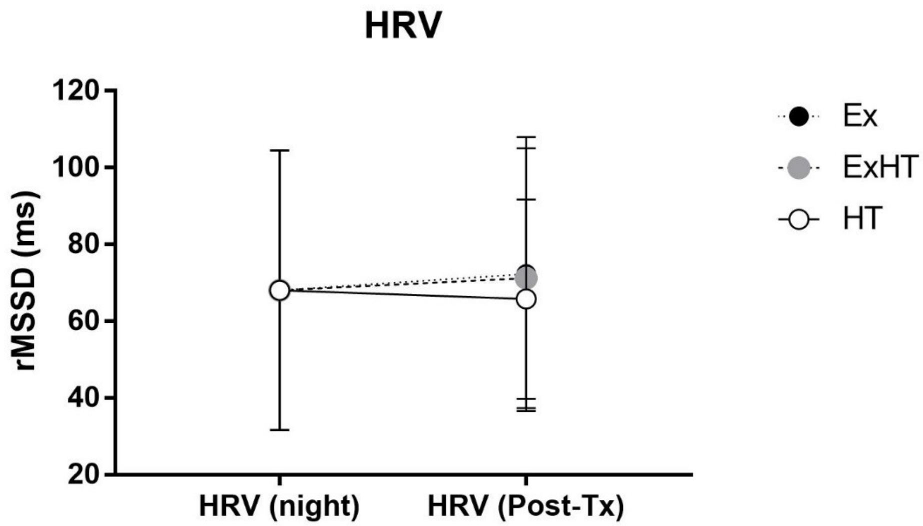

Fig 4: Overnight Heart Rate Variability (HRV) following no treatment [baseline; HRV (night)], Ex, ExHT, and HT.

IV. Discussion

Exercise training has been shown to influence autonomic nervous system function on short-and long-term nocturnal heart rate variability. Prior research has shown that immediate post-exercise parasympathetic values regarding heart rate variability were significantly lower than immediate pre-exercise parasympathetic values. This appears to not only be associated with exercise training but also, according to the data collected in this investigation, with the implementation of heat exposure. The fundamental purpose of this study was to examine the impact of acute exercise and heat therapy on nocturnal heart rate variability. Results indicate that nocturnal heart rate was lower following the 45-minute HT intervention when compared to Ex alone or ExHT combined; yet no intervention altered nocturnal heart rate variability. Heart rate variability is a non-invasive and comfortable way of monitoring any autonomic nervous system (ANS) imbalances. If an individual's body response is similar to fight-or-flight mode, the variation between heartbeats is low, so their heart rate variability is lower. A low heart rate variability is associated with stress, poor sleep, increased risk of death, and cardiovascular disease (Marcelo 2019). A scientific study shows that healthy elderly and middle-aged people who have a lower heart rate variability tend to have a higher chance of developing a stroke (Binici 2011). Thus, nocturnal heart rate variability is a strong indicator of the development of stroke in evidently healthy individuals.

Research has shown that heat therapy in the form of hot baths or saunas may provide numerous cardiovascular health benefits. Japanese Waon therapy is a form of heat therapy in which the entire body is warmed evenly in a dry sauna maintained at 60 degrees Celsius. Waon therapy has demonstrated to improve the hemodynamics, cardiac function, ventricular arrhythmias, vascular endothelial function, neurohormonal factors, sympathetic nervous system function, and symptoms in patients with chronic heart failure (Masaaki, Chuwa, 2011). In addition to that, repeated Waon therapy improves cardiac function and normalizes cardiac autonomic activity by increasing parasympathetic and decreasing sympathetic nervous system activity in patients with chronic heart failure. This is significant since chronic heart failure is characterized by sympathetic activation and parasympathetic withdrawal. Japanese Waon therapy is a novel and promising non-pharmacological approach for patients with chronic heart failure.

While exercise has shown to improve cardiovascular health, not enough people are utilizing exercise for it to make a relevant difference. These preliminary findings provide clinical significance on utilizing the combination of exercise and heat therapy as another alternative way to improve cardiovascular health.

V. Conclusion

Research did not support that the combination of acute exercise and heat therapy would decrease heart rate and increase heart rate variability. However, data revealed that heat therapy alone decreased nocturnal heart rate and no intervention altered nocturnal heart rate variability. This is important because our findings are consistent with the literature and research findings in terms of chronic and acute exercise training or heat therapy alone. This research has the potential to provide new avenues in the non-pharmacological treatment of hypertension by developing an exercise and heat exposure protocol, both of which are low-cost, low-risk, and readily accessible at home or in fitness centers. The results of this study have important health implications on the combination of exercise and heat therapy being utilized as alternative way to improve cardiovascular health.

Limitations

Data was collected from a sample size of six subjects, comprised of 3 males and 3 females between 20 to 35 years of age. The current sample size does not adequately represent the number of cases within the population. Therefore, research will be continued throughout the Summer of 2022 with the intent of completion by the Fall of 2022. The aim is to recruit additional subjects in equal numbers that are characterized as normotensive and hypertensive individuals. Heart rate variability was measured using a BioStrap wrist-based monitor which is similar to a fitness or activity monitor worn on the wrist. Although, the BioStrap is a simple, easy to use tool that is well-validated to monitor for heart rate variability. An electrocardiogram (EKG) is considered the gold-standard for the diagnosis of any heart conditions or abnormalities.

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