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An Examination of Physiological Responses During Simulated Occupational Stress Among EMT Students in a Hyperthermic Condition

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AN EXAMINATION OF PHYSIOLOGICAL RESPONSES DURING SIMULATED OCCUPATIONAL STRESS AMONG EMT STUDENTS IN A HYPERTHERMIC CONDITION

A Thesis

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in Partial Fulfilment of the

Requirements for the Degree

Master of Science

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Title: An Examination of Physiological Responses During Simulated Occupational Stress
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PURPOSE: The purpose of the present study is to observe the impact of a hyperthermic environment on physiological responses in EMT students performing a simulated occupational task. METHODS: Ten IUP EMT Students currently enrolled in the EMT Training course at the IUP Institute of Rural Safety and Health participated in the present study. Participants reported to the IUP Center for Sports Science Research and Education for the first visit, a familiarization session, in which signed consent, health history, and all resting anthropometrics were obtained. The familiarization session concluded with a maximal exercise test performed to determine the intensity for the subsequent simulated occupational task sessions. Following a minimum of 48 hours rest the participants returned to the laboratory for their first of two-exercise session. The environmental condition (hyperthermic and normothermic) was assigned in counterbalanced fashion. Both exercise sessions consisted of baseline values for body weight, urine specific gravity, heart rate, rating of perceived exertion (RPE), blood pressure, oxygen consumption (VO_2), skin temperature, core temperature and thermal sensation (TSS), outside the chamber and once again immediately upon entering the environmental chamber for all variables except body weight and urine specific gravity. Following 30 minutes of acclimation to the environment all variables are reassessed. Participants then completed a 10-minute treadmill walk at 70%-80% of their maximal heart rate. If a subject exceeded this range intensity was reduced to keep them at their desired intensity. Immediately following the treadmill walk, participants immediately transitioned to a sandbag (50 lb.) lift from the ground to a table (72in x 28.5in). Participants lifted the sandbag to a metronome. Participants were given 10 seconds to lift the sandbag onto the table top, and another 10 seconds to return the sandbag to the floor. This was repeated over the course of 5 minutes, until 15 lifts were successfully completed. After the sandbag lift, participants transitioned back to the treadmill to repeat the 10-minute walk at 70%-80% maximum heart rate. Once again, after the treadmill walk, participants transitioned directly to the sandbag lift for 5 minutes. Upon completion of the second sandbag lift, participants passively recovered in a seated position outside of the environmental chamber. Following 10 minutes of passive recovery all variables were reassessed. This concluded the study protocol. Participants were permitted to leave the laboratory once their heart rate fell within 20bpm of their initial resting value. Following a minimum of 48 hours rest, participants returned to the laboratory for the second exercise session. RESULTS: A two condition by nine time point analysis of variance (ANOVA) was conducted on all dependent variables. Post hoc analysis via paired samples t-test were conducted to further explain all main effects and interactions. A main effect of time was found for heart rate (HR) ($p = 0.006$), mean arterial pressure (MAP) ($p = 0.024$), rating of perceived exertion (RPE) ($p = 0.035$), oxygen consumption (VO_2) ($p = 0.009$), thermal sensation (TSS) ($p = 0.051$), core temperature ($p = 0.022$), mean skin temperature (MST) ($p = 0.000$) and mean body temperature (MBT) ($p = 0.003$). A main effect of condition was found for HR ($p = 0.001$), RPE ($p = 0.004$), TSS ($p = 0.000$), core temperature ($p = 0.033$), MST ($p = 0.015$) and MBT ($p = 0.010$). A significant time by condition interaction was seen in TSS ($p = 0.043$) and MST ($p = 0.033$) CONCLUSION: A hyperthermic environment causes significant changes to physiological response to exercise. EMT students were able to complete the occupational stress when an intensity of 70%-80% HR max was maintained. The high intensity nature of EMS work requires a higher level of physical fitness to succeed in the occupation. Fitness and nutritional information should be provided and encouraged for all first responders.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Background

Understanding the effects of temperature variation on human physiology is vital to recreational, sport, and occupational application. In occupations such as first responders and military personnel, hazardous environmental conditions are part of the job. First responders must perform occupational tasks during all temperatures and environmental conditions. These more strenuous jobs require intense bouts of physical activity throughout the course of a long shift. Movements executed by these first responders are also not simply aerobic or anaerobic. For this reason, building an assessment focusing solely on one metabolic pathway is not applicable (von Heimburg, 2007).

Common tasks among firefighters can be classified into fire suppression, alarm response, other non-fire emergencies, physical training and non-emergent clerical duties. Firefighters spend a varying amount of time performing each duty which can contribute to the associated risk (Kales, 2007). Emergency medical technicians (EMTs) perform awkward lifting and carrying of patients, stretcher carries, and anaerobic and aerobic movements that vary between emergency scenarios (Barnekow-Bergkvist, 2004). Many first responders struggle with the ability to execute the difficult tasks and place a serious amount of strain on their bodies and their cardiovascular system. A cardiovascular event is the number one cause of on-duty deaths among firefighters. This is also a prevalent cause of death in law enforcement officers and emergency medical technicians while on duty (Kales, 2007).

Another factor on the physical demands of first responders and military personnel is the use of body armor and personal protective equipment (PPE). These groups are sometimes required to wear body armor and different equipment loads in all of the activities that they must complete throughout the course of a shift. Wearing body armor causes higher energy expenditure to perform tasks as well as quicker time to fatigue. (Ricciardi, 2008). Ambulance work requires personnel to carry equipment to the scene that can induce physical strain on the neck and shoulders (Aasa, 2005). It is clear a variety of stressors contribute to the physical demands of first responders and their ability to safely perform work tasks. For this reason, it is important to objectively measure occupational task performance in a simulated occupationally and environmentally hazardous scenario.

Problem Statement

The above information leads to the conclusion that the current research shows many individual factors that contribute to the physical demands of first responders and military personnel. Specifically, very few studies are conducted with a population of EMS students and/or active personnel, yet this population is commonly exposed to awkward lifts, heavy equipment and gear, long shift work, and an increased risk of cardiovascular disease (Kales, 2007). Multiple studies have combined tests to see what could be the main cause of fatigue in first responders, but these tests are not performed simultaneously (Ricciardi, 2008, von Heimburg, 2007). A great majority of the literature in regards to first responders is specific to firefighters. Research regarding firefighters is relevant and necessary however, EMS workers are subject to similar occupational hazards. Measuring the physical demands of a simulated occupational task may lead to increased occupational efficiency among EMS personnel and a better understanding of how to perform these tasks in a more safe and effective manner.

Research Question

1. What are the effects of a hyperthermic condition on physiological variables such as blood lactate accumulation, oxygen consumption, core temperature, skin temperature, and heat strain index during a simulated occupational task in EMS students?

Hypotheses

1. I hypothesize that this study will demonstrate statistically significantly higher blood lactate accumulation in the hyperthermic condition during exercise when compared to the normothermic condition.
2. Heart rate (a), mean arterial pressure (b), RPE (c), oxygen consumption (d), thermal sensation (e), core temperature (f), skin temperature (g), mean body temperature (h) and respiratory exchange ratio (i) will be statistically significantly higher in the hyperthermic condition during exercise when compared to the normothermic condition.

Limitations

1. Subjects must be registered EMT students and complete Phase 1 regarding physical activity.
2. Possible participants were able to decline participation during the first phase of the study.

Assumptions

1. The subjects will attend all exercise sessions.
2. All subjects will give equal effort under both conditions.
3. All equipment will be working properly.
4. All guidelines and restrictions will be followed.
5. All subjects will adhere to fasting requirements.
6. All subjects will adhere to exercise parameters outside the study.

7. All subjects will be honest about physical activity and health habits.
8. Subjects will refrain from tobacco use and alcohol consumptions prior to the sessions.

Significance

It is important to test the effects of a hyperthermic environment on physiological responses because EMTs are exposed to extreme conditions with high physical demand. The literature on specifically EMTs is limited and EMT students, even more limited. EMTs are known to have a high prevalence of cardiovascular disease risk factors as well as low physical fitness levels (Thornton, 2014). By understanding the fitness level and response to exercise in EMT students we can begin to assess the needs for increased physical activity for this population.

Definition of Terms

EMS: Emergency Medical Services personnel, first responders that are involved in the first line of treatment and transportation in emergency situations.

Hyperthermic: Environmental extreme heat.

Hypothermic: Environmental extreme cold environment.

Mean Arterial Pressure (MAP): Mean arterial pressure is the average pressure during one cardiac cycle, calculated using the equation SBP + (2*DBP)/3.

Respiratory Exchange Ratio (RER): Respiratory exchange ratio gives the ratio of carbon dioxide produced from the metabolic system over the amount of oxygen used. This number can tell what energy system is being used primarily during exercise.

Rating of perceived exertion (RPE): Borg’s Rating of perceived exertion scale allows a subject to rate the amount of exertion they feel while performing a specific exercise bout.

Oxygen Consumption (VO_2): The amount of oxygen being used by a person at any given time, exercise or rest.

Heart rate (HR): The number of times per minute that the heart beats.

Thermal Sensation (TS): A rating of how cold or hot a person is feeling based on a scale from 1-9 with cue words along the scale.

Core Temperature (CT): The internal temperature of a person, measure using core temperature pills for the present study.

Mean Skin Temperature (MST): Mean skin temperature is measured through the use of skin thermistors place on the body in five different locations, calf, thigh, chest, tricep and forearm. Calculated using the equation: MST = (0.22*calf) + (0.28*thigh) + (0.28*chest) + (0.14*forearm) + (0.08*tricep).

Mean Body Temperature (MBT): Mean body temperature take an average of the core temperature and the mean skin temperature. Calculated using the equation: MBT = (0.64*core temperature) + (0.36*MST).

CHAPTER II

REVIEW OF LITERATURE

Physical Demands of First Responders

First responders can be classified as firefighters, police officers and emergency medical services (EMS) personnel. These occupations all require strenuous physical activity in high stress situations. The level of activity that is required when responding to an emergency can quickly induce fatigue (Kales, 2009). When a stressor is introduced the fight-or-flight response is triggered causing the adrenal glands to release two hormones, epinephrine and norepinephrine, that prepare the body to respond to the situation (Kenney, 2012).

When first responders are not responding to an emergency during a shift they tend to be heavily sedentary. The contrasting activities, from sedentary to high intensity actions, when handling an emergency causes a strain on the first responder (Barnekow-Bergkvist, 2004). Barnekow-Bergkvist et. al (2004) ran subjects through a battery of tests to determine what test would be the best indicator of an ambulance worker's time to fatigue. The subjects completed eight different tests over three visits. The tests were a loaded stretcher carry, VO_{2max} performed on a cycle ergometer, maximal isometric lifting strength, isometric back endurance, one-leg rising, one leg standing balance, and isokinetic shoulder and knee strength. The main results of this study were that maximal oxygen consumption and isometric back endurance were the best indicators of time to fatigue. Other important results seen in this study specifically pertaining to the loaded stretcher carry were a rating of perceived exertion of approximately 14-17 demonstrating a vigorous intensity for this activity and extended period of time above 70% of their peak heart rate while performing the task (Barnekow-Bergkvist, 2004).

The activities that are required of first responders are rarely in perfect conditions. Patients and objects at the scene of an emergency require immense amounts of strength to be utilized by the responding team. The lifting that is done on scene is often done in awkward positions that lead to less than ideal biomechanics being utilized by the first responder. There is a variety of medical equipment designed to make these situations less demanding of the first responder. Equipment is helpful in some situations but every emergency has its' own challenges. When performing a patient carry in various types of stair chairs, firefighters reported positives and negatives to the use of the equipment (Lavender, 2013). During a simulated activity with firefighters a VO_2 of 3.71 L/m was observed throughout the task involving a simulated rescue of hospital patients. The participants of this study were 14 part-time male firefighters. To complete the task each fire fighter had to climb six floors while carrying tolls, wearing protective clothing and a breathing apparatus. Once the ascent to the sixth floor was complete they had to safely guide six patients to a designated fire sheet. This study concluded that a minimum requirement for firefighters should be an absolute VO_{2max} of 4 L/min to allow for them to be able to meet the metabolic demands of the occupation (von Heimburg, 2007). Understanding the physical demands in any occupational situation for first responders begins with an understanding of normal physiological responses with exercise and increased exertion.

Physiological Responses to Exercise in Various Environmental Conditions

Years of both occupational and environmental observation and research have led to providing a set of expected physiological responses to exercise. These physiological responses play an important role in all aspects of daily activity. An understanding of expected outcomes under normal conditions allows for researchers to predict what physiological changes the body might undergo during stressful and abnormal circumstances. The normal response of increased heart rate and systolic blood pressure directly related to an increase in exercise intensity. Heart rate will increase with direct proportion to the exercise intensity. When exercising maximally, heart rate will plateau despite a continued increase in intensity. The point at which heart rate will no longer increase is known as maximum heart rate (MHR). Exercise intensity can be prescribed based on percentages of MHR and can use an estimated or actual value for MHR. Steady state exercise is a submaximal state of exercise at a desired intensity below the maximum heart rate at which heart rate can be maintained without increase. Increases in heart rate will cause a directly proportionate increase in systolic blood pressure as well. A person's diastolic blood pressure is not expected to change with exercise (Kenney, 2012).

Oxygen consumption (VO2) will increase with increases in exercise intensity. Oxygen consumption will increase gradually until a person reaches a maximal level of oxygen consumption known as VO_{2max}. This value is only seen once a plateau in VO_2 is observed, if the subject gives up prior to a plateauing the value is technically considered a VO_{2peak} and not VO_{2max}. VO_2 is measured in either absolute (L/min) or relative (ml/kg/min) terms. Average values for college aged men are between 44 and 50 ml/kg/min and for women are 38-42 ml/kg/min (Kenney, 2012).

During sub-maximal exercise intensities blood lactate accumulates at a rate that is equal to the rate at which it is removed (Moxnes, 2012). Blood lactate will increase gradually and then spike at a point known as the lactate threshold. Once a person reaches their lactate threshold the body is not removing lactic acid as quickly as it is being produced. This accumulation of lactate changes the pH in the muscle and causes muscular fatigue (Farrell, 2012). A link has been shown between blood lactate accumulation and fatigue. A person's level of fitness has a significant effect on their ability to remove lactic acid from the blood and perform for a longer period of time. Blood lactate accumulation leads to fatigue which can impact performance (Thomas, 2005).

Environmental factors impact these physiological responses in varying degrees. The intensity of the exercise as well as the extreme of the condition both should be considered when looking at physiological response. A cold environment causes an increase in energy expenditure. Shivering due to cold ambient temperature leads to an increase in oxygen consumption of up to 4 L/min just to maintain body temperature. The energy required to shiver depletes the substrates from which we gain energy at a faster rate than in a normothermic environment. Dietary carbohydrates should be increased to accommodate excess energy expenditure. When exercising in a cold environment for extended periods of time it is important to monitor the feet and legs for cold injuries. These areas are most commonly affected by cold injury as these types of injuries involve exposure to cold temperatures and water (Cheung, 2010). Heat illness and injury play a different role on the body than cold injury.

Heat stress can occur due to high exercise intensity, clothing that is not breathable and extreme temperature (Cheuvront, 2010). It places the body under immense amounts of stress to balance the physiological adaptations that are made to perform exercise in the heat. Cardiovascular, metabolic and thermoregulatory responses are all effected significantly with physical exertion in hyperthermic conditions (Armstrong, 2003). The combination of heat and exercise place the body under immense stress and produce different physiological responses than those seen under normal conditions.

Hyperthermic Conditions and Exercise

Exercising under various environmental conditions will produce different physiological outcomes. Hyperthermic conditions put the body at risk of heat illness because of the drastic differences in physiological responses. Increased core temperature during exercise in the heat is a cause of increased metabolic demands and lead to increased cardiovascular responses (Armstrong, 2003).

Exertional heat illness is most frequently observed in a hot environment but can also be seen in normal conditions when core temperature increases to a dangerous level. Exertional heatstroke occurs with a rectal temperature greater than 40°C and central nervous system (CNS) impairment. The signs and symptoms of heatstroke are extreme thirst, fatigue, weakness, chills, behavioral changes, impaired gross motor function, deliria, memory loss and syncope. Early treatment is essential to the prevention of more serious complications of the CNS. Heat exhaustion causes an inability to exercise due to extreme fatigue that is likely due to dehydration and the increased energy expenditure associated with heat stress. It can cause syncope but unlike heatstroke rectal temperature does not exceed 40°C and CNS impairment is not seen. Dehydration, muscle fatigue and excess salt loss are causes of heat cramps. Heat cramps are more common in individuals of lower fitness level and that are not properly acclimated to the condition. Exertional hyponatremia happens with excessive sodium loss and is commonly observed in prolonged periods of exercise. Excessive fluid intake and sweat induced sodium loss with improper electrolyte balance are typical causes of exertional hyponatremia (Armstrong, 2003). Awareness of the signs, symptoms and causes of these illnesses is detrimental to proper treatment and prevention.

Hyperthermic exercise conditions impact the cardiovascular system to keep up with the increased metabolic demands. Increased skin temperature requires excess blood flow to the skin which is one cause of the faster HR increase that is visualized with exercise in the heat. There is also a decrease in stroke volume when exercising in hyperthermic conditions (Cheuvront, 2010).

Sweating is another way the body adapts to exercise to maintain core temperature. Evaporation of sweat on the surface of the skin allows for a cool feeling aiding in thermoregulation. This is only effective as a cooling mechanism if the body has sufficient fluids to avoid dehydration (Cheuvront, 2010).

Exercise performed in hyperthermic conditions increases the rate of metabolism (Tyka, 2009). Aerobic and anaerobic movements cause a build-up in lactic acid. More intense movements and exercise cause a higher increase in blood lactate (Paoli, 2010). Blood lactate accumulation occurs at a faster rate in hyperthermic conditions (Lorenzo, 2011). Aerobic exercise at a level below the lactate threshold will allow the body to clear the lactate as it is being produced (Paoli, 2010). Heat acclimation can help in reducing the rapid accumulation of blood lactate. (Lorenzo, 2011). The faster increase in blood lactate accumulation in heat is believed to be due to increased utilization of fast-twitch skeletal muscle fibers as well as a reduction in removal of blood lactate (Tyka, 2009).

Hyperthermic conditions have been observed to decrease the time to fatigue when performing maximal and submaximal exercise (Parkin, 1999; Lorenzo, 2011). Many factors are thought to play a role on why we see a decreased time to fatigue in hyperthermic conditions. The physiological responses that impact time to fatigue cannot be pinpointed to one or two responses. A variety of physiological responses such as core temperature, brain temperature, substrate depletion, central nervous system impairment, and contractile protein damage all impact a person’s time to fatigue under heat stress (Cheung, 2004).

Core temperature is hypothesized to play a role on fatigue in hyperthermic conditions. Cheung et al. (2004) reported that in active individuals a rectal temperature of 38.7°C was the point of exhaustion despite level of hydration or acclimation time. Rectal temperature increases at a faster rate in a hot environment than in a thermoneutral environment when performing the same amount of work (Tyka, 2009). Increased aerobic fitness level aids the regulation of rectal temperature under heat stress. Body composition also impacts rectal temperature increase and lower rates of adiposity have shown reduced rate of temperature increase (Cheung, 2004).

Understanding the basic physiological responses that are expected in hyperthermic conditions allows for exercisers and exercise professionals to maintain safe practices during activity in hot conditions. Hyperthermic conditions are unquestionably important when observing first responders. A study done in the UK in 2008 demonstrated that in hyperthermic conditions 25% of firefighters being studied were not able to complete a simulated work task. Firefighters were asked to perform a rescue of a manikin located 45m from the starting point in an environmental condition of 27°C and 50% humidity. Two responders were instructed to enter the building with a standard firefighting hose and a breathing apparatus and exit the building with the manikin using the same path used to enter the scenario. The test was terminated if a core temperature of 39.5°C was reached, the firefighter felt their air pressure was low in the breathing apparatus, Fire Safety Officers judged the situation to be unsafe, or when the team successfully completed the task. The subjects performed the task under 4 different conditions, extended duration breathing apparatus and standard duration breathing apparatus with a 45mm hose and a 70mm hose. The four conditions were performed by eight teams of firefighters and of all 32 attempts only four successes occurred. This study also demonstrated that in all conditions the subject’s mean heart rate was considered “hard” based on their percentage of heart rate reserve and classified using Howley’s classification of intensity (60%-84% HRR) (Richmond, 2008). The physically demanding nature of emergency scenarios place first responders under a large amount physical stress for extended periods of time.

Coronary Heart Disease Risk and Health Habits in First Responders

A variety of factors impact the health of first responders, high levels of stress, physically demanding tasks and shift work causing chronic sleep deprivation. The sum of these factors over the span of a lifetime plays a detrimental role in the health and well-being of first responders (Rodgers, 1998). A shift for these workers is usually either 12 or 24 hours. The Occupational Safety and Health Administration (OSHA) defines a normal shift as being 8 hours in length (Weaver, 2015). Stress plays an impact on the lives of all first responders and can be associated with many aspects of the occupation. These jobs are not only stressful physically but also psychologically. EMTs specifically have reported very high levels of stress at the end of a shift. They also report that they are mentally drained and worn out following work. High levels of stress can lead to errors in performance, job dissatisfaction and a negative attitude towards patients (Cydulka, 1997). First responders experience many conditions that make them more at risk for cardiovascular disease risk factors. This population generally does not exercise regularly, have poor nutritional habits, sleep deprivation that leads to chronic exhaustion and post-traumatic stress disorder (PTSD). The occupational setting is not always conducive to changing these patterns. Sleep and nutritional habits are often due to the lack of availability while working. Many first responders work long shifts and on a rotating schedule which impacts not only their sleep schedule but also the availability of nutritional options for meals (Kales, 2008). The traumatic situations that are endured day in and day out by first responders lead to many psychological issues as well. Post-traumatic stress disorder is associated with poor physical health as well as many psychological issues (Hegg-Deloye, 2014).

Hypertension was seen in approximately 75% of first responders and can largely be contributed to these lifestyle factors (Kales, 2009). In a study of 470 law enforcement officers only 32% were considered exercisers which meant they exercised for a minimum of 20 minutes, three times per week and for at least four weeks. When compared to their non-exercising counterparts in a battery of fitness testing they demonstrated better results in VO_{2peak}, body fat percentage, flexibility, muscular endurance, and a lower 10-year risk of developing cardiovascular disease. Oxygen consumption was estimated by time to fatigue, muscular endurance was evaluated by the number of sit-ups performed in one minute and lower back flexibility assessment through the sit-and-reach test. The subjects were divided into five groups by age and each test was analyzed independently to look for significance between exercisers and non-exercisers as well as difference by age. The maximal oxygen consumption was significantly different between exercise groups as well as between the three oldest age groups. A statistically significant lower risk of cardiovascular disease in the next 10 years was seen between the exercisers and non-exercisers in the >48 age group. Mean scores for all tests were better for the exercise group which provides evidence supporting the importance of exercise among this population (Franke, 1994).

A cardiovascular event caused by coronary heart disease and cardiometabolic risk factors was found to be the cause of 45% of deaths that occur among firefighters in the United States. The on-duty deaths were analyzed by task being performed at time of death as well to evaluate for a potential relationship between death specific tasks. Fire suppression was responsible for 32.1% of the 45% of deaths by cardiovascular disease. Other tasks observed and their respective percentages of deaths were responding to an alarm (13.4%), returning from an alarm (17.4%), engaging in physical training (12.5%), responding to non-fire emergencies (9.4%), and nonemergency duties (15.4%). Twenty-two percent of on-duty deaths of law enforcement officers were related to existing cardiovascular disease. Eighteen percent of EMT deaths on-duty were caused by cardiovascular disease (Kales, 2007). It is estimated that 75% of emergency responders have elevated blood pressure putting them at a higher risk for cardiovascular disease. Many EMT personnel are obese or overweight and can have a cluster of risk factors associated with their body weight (Kales, 2009). The high prevalence of cardiovascular risk factors among this population is one factor that can explain the large amount of on-duty deaths that are caused my cardiovascular disease.

Physical fitness levels in first responders tend to be below average following initial training. A study of firefighter academy students showed that following the academy there is no formal physical training but the graduated students were expected to maintain their fitness level (Cornell, 2017). Volunteer firefighters in rural settings have little to no health or fitness requirements for recruits (Gaetano, 2007).

Need to Assess Occupational Performance in EMS Personnel

The strenuous and stressful nature of first responders places them at a higher risk for cardiovascular disease (Kales, 2007). As a part of public health and safety it is essential to have an expert work force of first responders. One of the factors defined in emergency preparedness regarding public health was a community's ability to responder with volunteer and paid emergency responders (Nelson, 2007). Many of the cardiovascular risk factors seen among EMTs are modifiable risk factors that could be reduced through lifestyle changes. Health risk and poor behaviors are more common among EMTs than the national average (Pirralo, 2005).

Working extended shifts, specifically between 12 and 16 hours, was shown in a study of all OSHA reported injuries in 14 different EMS agencies to increase the risk of injury while at work (Weaver, 2015). Sprains and strains were the most common injury found in the study conducted by Weaver et. al which coincides with a study of musculoskeletal injuries done on

Swedish EMS workers (Aasa, 2005). Aasa et. al examined the psychological and physical injuries that were self-reported by 1,187 EMS personnel. Neck-shoulder and lower back strains were reported by 205 of those workers. The injuries experience while working caused limitation of activity as well as sick leave in some cases (Aasa, 2005). Occupational fatalities in emergency medical service personnel were caused by a variety of occupational tasks. The largest contributor to the number of fatalities was found to be ground transportation followed by air ambulance crash, cardiovascular event, and homicide respectively. A few EMS deaths were found to be atypical and not associated with a specific task or duty (Maguire, 2002).

Musculoskeletal injury was found to be the leading cause of early retirement in a study of 534 ambulance personnel. The secondary cause of early retirement in both males and females was circulatory issues (Rodgers, 1998). Previously discussed studies demonstrated that physical fitness level and the physically demanding nature of the occupation places first responders at a high risk for a cardiovascular event and could prevent them from completing work tasks (Cornell, 2017; Kales, 2007; Barnekow-Bergkvist, 2004). The Health-Related Fitness Test (HRFT) is a pre-employment test that is starting to be utilized by Australian ambulance services to evaluate physical fitness level related to activities that are applicable to ambulance work. Rankings for the HRFT score performance on a scale from 0-4, currently a minimum score of 1 in each section is required amongst EMS personnel (Thornton, 2013).

Thornton et. al utilized the HRFT protocol on 251 Australian paramedic students to evaluate HRFT as well as differences between male and female students. Five of the students did not complete the test battery with a passing score. Males had significantly higher overall scores than females. The researchers also analyzed weaknesses within the HFRT and its efficacy of predicting the success of a paramedic based on pre-employment scores (Thornton, 2013).

Low fitness levels and poor health conditions are increasing the occupational risk for EMTs. Increasing exercise can reduce the risk of cardiovascular risk factors and could possibly reduce the risk of physical injury on the job as well. The Tactical Strength and Conditioning Report theorizes that increased fitness levels could reduce injury rates in first responders. High-intensity and Olympic style lifting is closely related to the motions executed by EMTs and could help teach safer lifting practices while on the job as well as strengthening the areas that are weakened and often injured among EMT workers (Fass, 2014). Research clearly presents an issue in the population of EMS workers. The next step is to figure out how to prevent these issues and what steps can be taken to increase the fitness levels of EMTs to reduce the risk of injury and cardiovascular disease related illness and death.

CHAPTER III

METHODOLOGY

Subjects

The subjects for this study were students, age 21-29, currently or recently enrolled in the Indiana University of Pennsylvania EMT Training class. Cornell et. al (2017) completed a study of firefighter academy students with varying ages, the oldest being 43 years of age. These students were completing physically demanding tasks while training to become firefighters. The present study was available to 18-43 year-old subjects to safely conduct exercise sessions while still allowing for a variety of subjects.

Recruitment

Recruitment took place in the classroom for the EMT Training at the Institute of Rural Safety and Health as well as the Center for Sport Science Research and Education during the spring 2018 semester.

Procedures

Subjects have completed the first phase of the study, related to physical activity levels and health habits. The first phase of the study required the students to complete combination of four surveys and questionnaires that assessed behavioral risk factors regarding personal and occupational behaviors. The surveys that were completed were a combination of the following, modified Center for Disease Control and Prevention (CDC) Behavioral Risk Factor Surveillance System (BRFSS) questionnaire, seatbelt use and motor vehicle driving questions adopted from the US National Highway Traffic Safety Administration’s (NHTSA’s) Motor Vehicle Occupant Safety Survey (MVOSS), and the Modifiable Activity Questionnaire (MAQ). Both phases were completed on a voluntary basis. The completion of the first phase qualified the subject for the second phase of the study.

Subjects were asked to come prepared for exercise during the first session. Participants were asked to refrain from eating and alcohol consumption 3 hours prior to the sessions. Subjects could not have any current signs or symptoms of cardiovascular, renal or metabolic disease. The contraindications for exercise are directly related to the American College of Sports Medicine Guidelines for Exercise Testing and Prescription. This text establishes safe practices for exercise (ACSM, 2017).

Familiarization

The first session was a familiarization session and took place in the Human Performance Laboratory, Zink Hall 111, and subjects began by completing the informed consent form. Following consent for voluntary participation in the study, the subjects completed demographics and medical history. Resting values for heart rate and blood pressure were measured with a Polar heart rate monitor and a blood pressure cuff with sphygmomanometer, respectively. If the resting blood pressure exceeds 140/90mmHg the subject will not proceed with exercise. The American College of Sports Medicine Guidelines to Exercise Testing and Prescription defines safe practices for exercise professionals to follow. A blood pressure of 140/90mmHg or higher at rest would be unsafe to begin exercise because of the increase in blood pressure that will be seen with exercise (ACSM). Height and weight were assessed by an eye level weigh beam physician scale with a height rod and body composition through the use of the BodPod. Next, the subject completed a modified Balke treadmill test to determine the intensity at which they exercised for the second and third sessions. Prior to beginning the protocol the subjects were familiarized with Borg's Rating of Perceived Exertion (RPE) Scale from 6-20. The participants walked at 3.3 mph through the duration of the test with the grade increasing by 2.5% every 2 minutes until the subject reaches a plateau in oxygen consumption, a RPE score of 20, or volitional fatigue. The subject was instructed to signal to the principal investigator when they could no longer continue with the exercise test. Values were observed throughout the duration of the exercise test, if oxygen consumption is no longer increasing or begins to decrease the test will be terminated and maximum value will be recorded. Maximal heart rate and VO_2 were determined from this exercise test and utilized to determine intensity for the second and third sessions of the study. The subject was also familiarized with the sandbag lift and the metronome to which they will perform the lift for subsequent sessions 2 and 3, outlined below.

Sessions 1 & 2

Following a minimum of 48 hours rest from the previous session the subjects were asked to report to the Human Performance Lab as they did for the first session. Subjects were given a t-shirt and shorts upon arrival so that all subjects performed the protocol in the same attire. Resting values were recorded for heart rate, blood pressure, and blood lactate accumulation. Blood lactate accumulation was obtained through a finger stick and analyzed with blood lactate analyzer and test strip. Nude body weight was recorded before beginning the protocol. Urine specific gravity was used to assess hydration prior to entering the chamber. Core temperature was monitored following original resting values and prior to entrance into the environmental chamber. Skin thermistors were placed prior to entering the environmental chamber. Subjects then performed the simulated work tasks in normothermic (normal) or hyperthermic (hot) conditions in counterbalanced fashion. The hyperthermic environment was 100° F and 60%-70% humidity. The subjects were placed in the environmental chamber for 30 minutes of acclimation to each condition. Following the acclimation, the subjects were asked to wear the Hans-Rudolph VO_2 mouthpiece and head set so that oxygen consumption can be monitored throughout the test. The simulated work activity consisted of 10 minutes walking on the treadmill at an intensity of

70%-80% of their maximum heart rate that was established from the first session (Gaetano, 2007). During the final two minutes of the treadmill walk, heart rate, blood lactate accumulation, blood pressure, RPE, TSS, VO_2, skin temperature and core temperature were recorded again. Next, subjects were asked to lift a 50lb sandbag (simulating a patient) from the ground to a table (72inx28.5in) for 5 minutes. A total of 15 lifts were performed, giving the subject 10 seconds to bring the sandbag to the table and 10 seconds to place the sandbag back down to the floor. A metronome sounded every second, while the principal investigator cued the participant every 10-second interval for each lift onto and off the table. Following the 5 minutes of lifting, all dependent variables were measured again. The subject then repeated those actions for a second time, beginning with another 10-minute walk on the treadmill followed by 5 minutes of sandbag lift. The subject then underwent a passive cool down outside of the chamber for 10 minutes and all dependent variables were measured, completing the data collection for that session. After the cool down values are recorded, the subject removed the Hans-Rudolph mouthpiece and skin thermistors. The subject's nude body weight was measured to assess weight loss, and urine specific gravity assessed hydration changes during the session. Nude body weight was performed in a private bathroom with a male researcher for male subjects and a female researcher for female subjects. Monitoring of the subject's heart rate continued during a cool down of their choice either passive, treadmill walking, or cycling, until they returned to a heart rate 20 bpm above the initial resting value. The subject was then thanked for their time and participation as well as given compensation for their time.

Time

The first session was completed in approximately 1 hour, the second and third sessions were approximately 1 hour and 30 minutes requiring approximately 4 hours of time for each subject. Prior to completing the next session subjects needed a minimum 48 hours rest. Most participants completed the study in 7-10 days.

The second and third sessions contained the simulated occupational task. For both sessions the collection of all dependent variables will go as follows:

Baseline values outside of the chamber started with resting heart rate, blood pressure, nude body weight, core temperature, skin temperature, rating of perceived exertion, oxygen consumption, and blood lactate accumulation. Repeated measurements for heart rate, blood pressure, core temperature, skin temperature, rating of perceived exertion, oxygen consumption and blood lactate accumulation were repeated immediately upon entrance into the environmental chamber to establish a secondary environmental baseline value. The subject then underwent a thirty-minute seated acclimation to the environmental condition and the seven variables that were established for the environmental baseline were be repeated. Subjects performed a 10-minute treadmill walk at 70%-75% of their heart rate maximum with heart rate, RPE, thermal sensation, core temperature and skin temperature being monitored every minute. The same eight variables were repeated during the last two minutes of the 10-minute treadmill walk. The next stage of the occupational task was a five-minute sandbag lift, following which the variables were recorded again. Both the treadmill walk and sandbag lift were repeated a second time with variables being recorded following each. Subjects were removed from the chamber and all variables will be recorded again. A ten-minute passive cool down occurred outside of the chamber and all variables were recorded for the final. Following the passive cool down subjects were asked to complete a passive cool down or active cool down on the treadmill or cycle ergometer if heart rate had not returned to a value within 20 bpm of the initial resting value.

Instruments

The study was completed using a variety of assessment tools to evaluate heart rate, blood pressure, body composition, core temperature, oxygen consumption, RPE and repetitions. The following tools were used:

Polar Heart Rate Monitor: this was worn by the subjects throughout the duration of each session. It recorded their heart rate using a chest strap and a wristwatch display.

Continental Health-o-meter Physician's Scale: this tool used eye level weigh beam physician scale with a height rod to measure body weight and height. The scale is located in the Human Performance Lab in Zink Hall.

Aneroid Sphygmomanometer: this was used for assessing systolic and diastolic blood pressure and is known as a blood pressure cuff and is paired with a stethoscope to listen for the Korotkoff sounds that express blood pressure.

Borg's Rating of Perceived Exertion (RPE) Scale: was used to assess an individual's perceived exertion during each session. This is a scale from 6-20 and is designed to represent heart rate from 60-200 beats per minute. The subject was instructed that a RPE of 6 is equivalent of sitting in a chair while a RPE of 20 is the hardest they can work, a maximal effort.

Thermal Sensation Scale: this scale was used for subjects to rate the environmental conditions on a scale from 1 to 9 representing cold to hot, respectively.

Accu-chek Safe-T-Pro: sterile single use lancets were used for drawing blood to be analyzed for blood lactate accumulation.

Lactate Scout +: blood lactate analyzer that uses lactate scout sensor strips to collect blood from the finger following a stick from the Accu-chek lancet.

HQInc. Wireless Sensing System: this monitored core temperature through detection of the CorTemp Ingestible Core Body Temperature Sensor that wirelessly transmits core body temperature as it travels through the digestive tract. The recorder picks up the wireless signal from the CorTemp sensor and converts that signal into a digital format, displaying the temperature.

Skin Thermistors: ITP082-25, Nikkiso - Therm Co., Ltd., Japan, five skin thermistors are place on the right side of the body, at the middle of the posterior calf, middle of the anterior thigh, just above the pectoralis on the chest, middle of the posterior tricep and the middle of the posterior forearm.

TrueOne 2400 Metabolic Measurement System: this analyzed the expired gas and recorded the subject's oxygen consumption throughout each session. It will also be used in finding the subjects maximal oxygen consumption or VO_2max.

Hans-Rudolph Valve: this is the mouthpiece that allowed the subject to breathe room air while expired gasses were sent into the metabolic cart for analyzing. This mouthpiece is attached to a headset which allowed the subject a larger range of motion while still collecting all expired gas.

BodPod: One of the most accurate measures of body composition. The BodPod measured the amount of air displaced upon entering the chamber and uses an estimated lung volume to accurately measure body fat percentage.

Environmental chamber: this was used to control the conditions in which sessions 2 and 3 were performed.

Treadmill: subjects completed the walking portion of the study on a treadmill located inside the environmental chamber.

Sandbag: this was used to simulate a lift that would be done in the field. The sandbag will weigh 22.7kg (50lbs) which is a weight that is deemed safe for one person to lift independently.

Metronome: the principal investigator used the cell phone application "MetroTimer" to keep the repetitions of the sandbag lift at a consistent cadence.

Table: 72inx28.5in table that was used for placement and completion of 1 repetition of the sandbag lift.

Mean Skin Temperature (MST): Calculated using the following equation: (0.22*calf temperature) + (0.28*thigh temperature) + (0.28*chest temperature) + (0.14*forearm temperature) + (0.08*triceps temperature) =MST, all temperatures were recorded in degrees Celsius.

Mean Body Temperature (MBT): Calculated using the following equation: (0.64*core temperature) + (0.36*MST) =MBT, all temperatures were recorded in degrees Celsius.

Mean Arterial Pressure (MAP): Calculated using the following equation: ((SBP+2)*DBP)/3 =MAP in mmHg.

Research Design and Statistical Analysis

This is a within-subjects design in a counterbalanced fashion. All data was evaluated for normal distribution. Normal distribution was not found in every timepoint of each variable. This is believed to be related to the small sample size. Parametric testing was done for each variable. Descriptive statistics were used to describe the subjects' anthropometrics and baseline values measured at the familiarization session. A 2 condition x8 time points analysis of variance (ANOVA) will be utilized to ascertain effects of heat on all dependent variables.

CHAPTER IV

RESULTS

Participants

Thirteen EMT students from Phase 1 had indicated an interest in participating in the study, however only ten EMT students (8 male; 2 female) completed this study in its entirety. One female who completed half of the study dropped out due to scheduling conflicts. Two additional female participants had scheduled their familiarization sessions and failed to show up to participate in the study. Table 1 presents demographic data of the ten EMT students who completed the study. Data that was normal in the descriptive characteristics is expressed as mean ± standard deviation, data that was not normally distributed is expressed as median [interquartile range]. The median age for the study sample was 23.50 [21.75-26.00] years. The percentage of males was 80% and females 20%. Mean body fat percentage was 24.62% ± 12.44%, median height was 69.50 in. [68.50 in.-71.13 in.] and median weight was 188.20 lb. [156.0 8 lb. -228.33 lb.]. Resting values were recorded at the familiarization session to establish a baseline for the group. Average resting heart rate was 76.73 ± 16.94 bpm and mean resting blood pressure was 121.21 ± 9.35/70.55 ± 8.72 mmHg. The data was analyzed for normality and many inconsistencies within each variable were found. This is likely due to the small sample size and split of fit and unfit subjects.

Table 1

Descriptive Characteristics of the EMT students

Age (years)	Height (in.)	Weight (lbs.)	Body Fat **(%)**
23.50 [21.75-26.00]	69.50 [68.50-71.13]	188.20 [156.08-228.33]	24.62 ± 12.44
VO_2max (mL/kg/min)	Resting HR (bpm)	Resting BP (mmHg)	Max HR (bpm)
49.70 ± 15.78	76.73 ± 16.94	Systolic: 121.27 ± 9.35 Diastolic: 70.55 ± 8.72	185.50 [182.25-193.75]

Note. Values are reported as mean ± standard deviation and median [interquartile range].

Hypothesis 1 stated that blood lactate accumulation will be statistically significantly higher in the hyperthermic condition. After running a 2-condition x 8 time points ANOVA, the null hypothesis was accepted. There is no statistically significant condition by time interaction (F = 4.479, *p* = 0.123) or main effect of condition (F = 1.069, *p* = 0.328) (Table 2). There is a statistically significant main effect of time (F = 2.306, *p* = 0.037) (Table 2). Figure 1 shows the relationship between the normothermic and hyperthermic conditions. Post-hoc analysis shows no explanation for the main effect of time (Table 3). The limited sample size is the most likely explanation for this.

Table 2

Mixed Model ANOVA: Blood Lactate

Effect	F	df	*p*
Time	2.306	7	0.037
Condition	1.069	1	0.328
Time*Condition	4.479	7	0.123

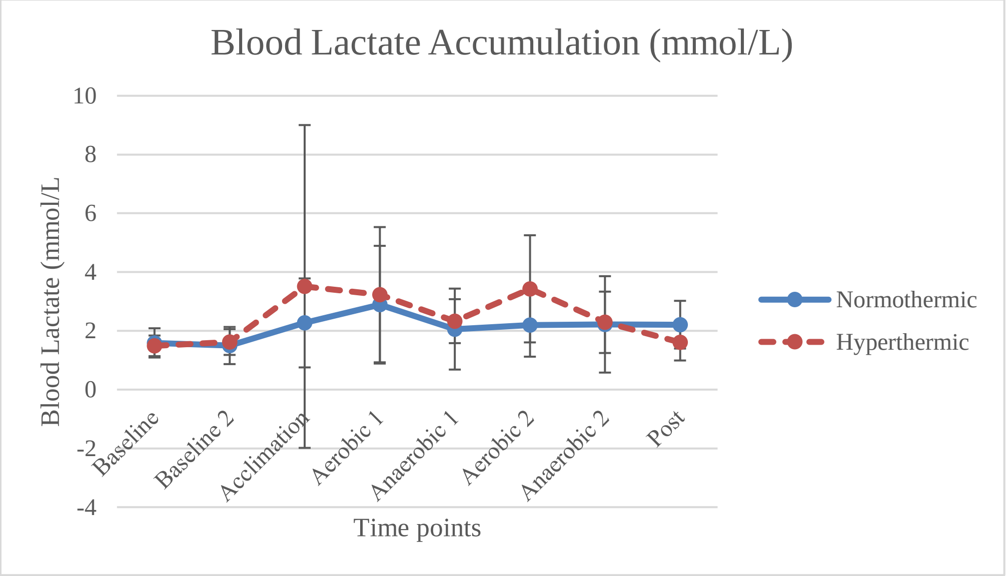

Figure 1. Blood lactate accumulation. Change in blood lactate accumulation over 8-time points in both environmental conditions.

Table 3

Blood Lactate Data

	Normothermic	Hyperthermic
Baseline 1	1.590 ± 0.498	1.490 ± 0.351
Baseline 2	1.500 ± 0.632	1.620 ± 0.439
Acclimation	2.270 ± 1.514	3.510 ± 5.493
Aerobic 1	2.890 ± 2.003	3.230 ± 2.301
Anaerobic 1	2.060 ± 1.378	2.330 ± 0.748
Aerobic 2	2.200 ± 1.079	3.430 ± 1.823
Anaerobic 2	2.220 ± 1.640	2.290 ± 1.044
Post	2.210 ± 0.812	1.610 ± 0.619

Note. Data are mean ± SD. Values are presented in millimoles per liter (mmol/L).

Hypothesis 2A stated that heart rate in the hyperthermic condition will be higher during exercise. After running a 2-condition x 8 time points ANOVA, the null hypothesis is accepted. There is a statistically significant condition by time interaction (F = 10.904, $p < 0.001$) (Table 4). There is a statistically significant main effect of condition (F = 21.651, $p = 0.001$) and main effect of time (F = 140.847, $p < 0.001$) (Table 4). Figure 2 shows the relationship between the normothermic and hyperthermic conditions. Post-hoc analysis via paired samples t-test reveals that heart rate increased significantly at the onset of exercise, aerobic 1, compared to baseline ($p < 0.001$), was statistically significantly higher in the second anaerobic exercise bout when compared to the first anaerobic bout ($p < 0.040$) and decreased significantly compared to anaerobic 2 after exercise was stopped ($p < 0.001$) (Table 5). The hyperthermic condition showed a significantly higher heart rate at all timepoints compared to the normothermic condition (t = 6.336, p < 0.001) with the exception of aerobic 2 ($p = 0.509$) and post-exercise ($p = 0.102$) (Table 5).

Table 4

Mixed Model ANOVA: Heart Rate

Effect	F	df	*p*
Time	140.847	7	<0.001
Condition	21.651	1	0.001
Time*Condition	10.904	7	<0.001

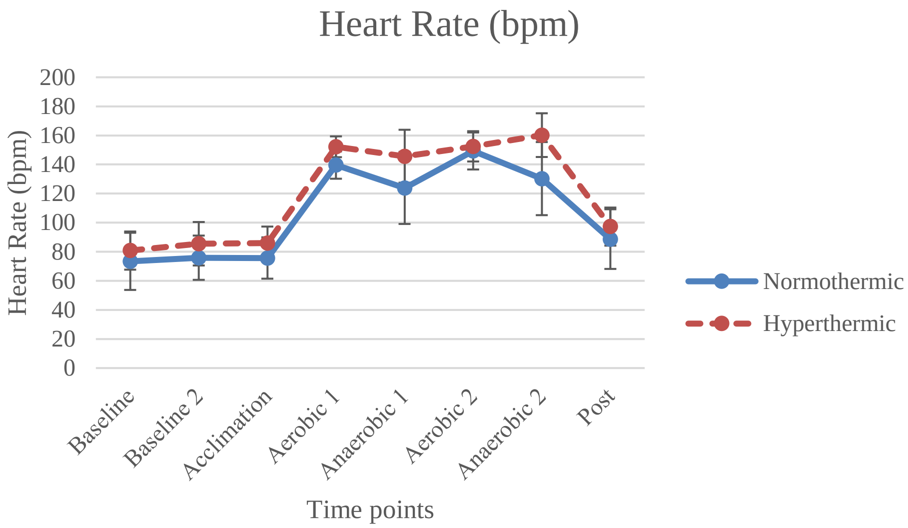

Figure 2. Heart rate. Change in heart rate over 8-time points in both environmental conditions.

Table 5

Heart Rate Data

	Normothermic	Hyperthermic
Baseline 1	73.400 ± 19.659	80.800 ± 13.122#
Baseline 2	75.900 ± 15.220	85.500 ± 14.946#
Acclimation	75.700 ± 14.213	86.000 ± 11.314##
Aerobic 1	139.600 ± 9.393**	152.200 ± 7.162**#
Anaerobic 1	123.900 ± 24.786**	145.700 ± 18.191**##
Aerobic 2	149.300 ± 12.711**	152.500 ± 10.416**
Anaerobic 2	130.300 ± 25.135**	160.200 ± 15.039**##
Post	88.700 ± 20.516*	97.300 ± 13.098*

Note. Data are mean ± SD.
*$p < 0.05$, significantly higher compared to baseline in both conditions.
**$p < 0.001$, significantly higher compared to baseline in both conditions.
#$p < 0.05$, significantly higher in the hyperthermic condition compared to normothermic condition.
##$p < 0.001$, significantly higher in the hyperthermic condition compared to normothermic condition.
Values are presented in beats per minute (bpm).

Hypothesis 2B stated that mean arterial pressure (MAP) in the hyperthermic condition will be higher during exercise. After running a 2-condition x 8 time points ANOVA, the null hypothesis is accepted. There is not a significant condition by time interaction (F = 0.789, p = 0.599) (Table 6). There is a not significant main effect of condition (F = 0.441, p = 0.523) (Table 6). There is a significant main effect of time (F = 11.681, $p < 0.001$) (Table 6). These results can be seen in Figure 2. Post-hoc analysis reveals that MAP increases statistically significantly at aerobic 2 (p = 0.014) and anaerobic 2 (p = 0.007) when compared with the baseline 2 values (Table 7).

Table 6

Mixed Model ANOVA: Mean Arterial Pressure

Effect	F	df	*p*
Time	11.681	7	< 0.001
Condition	0.441	1	0.523
Time*Condition	0.789	7	0.599

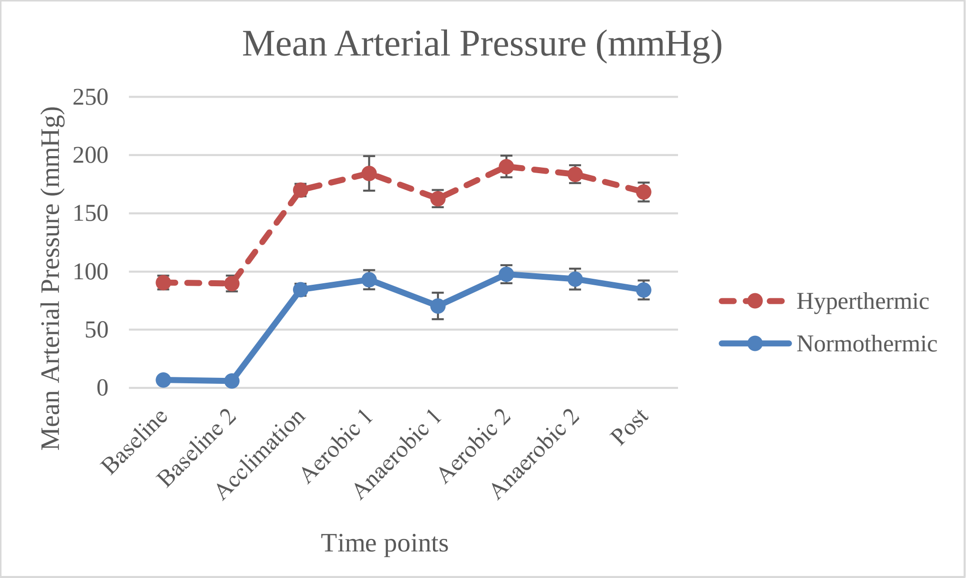

Figure 3. Mean arterial pressure. Change in mean arterial pressure over 8-time points in both environmental conditions.

Table 7

MAP Data

	Normothermic	Hyperthermic
Baseline 1	6.785 ± 1.474	83.733 ± 5.915
Baseline 2	5.955 ± 1.679	83.733 ± 6.771
Acclimation	84.333 ± 5.157	85.600 ± 5.344
Aerobic 1	92.933 ± 8.238	91.333 ± 14.841
Anaerobic 1	70.400 ± 11.384	92.200 ± 7.397
Aerobic 2	97.667 ± 7.762*	92.533 ± 9.300*
Anaerobic 2	93.467 ± 8.954*	90.133 ± 7.671*
Post	84.133 ± 8.158	84.133 ± 8.097

Note. Data are mean ± SD.
*$p < 0.05$, significantly higher compared to baseline in both conditions.
**$p < 0.001$, significantly higher compared to baseline in both conditions.
#$p < 0.05$, significantly higher in the hyperthermic condition compared to normothermic condition.
##$p < 0.001$, significantly higher in the hyperthermic condition compared to normothermic condition.
Values are presented in millimeters of Mercury (mmHg).

Hypothesis 2C stated that rating of perceived exertion (RPE) in the hyperthermic condition will be higher during exercise. After running a 2-condition x 8 time points ANOVA, the null hypothesis is accepted. Figure 3 demonstrates these results. There is not a significant condition by time interaction (F = 3.990, p = 0.001) (Table 8). There is a significant main effect of condition (F = 14.211, p = 0.004) and main effect of time (F = 71.663, p < 0.001) (Table 8). Post-hoc analysis demonstrates a difference at the aerobic 2 (t = 3.000, p = 0.015) and anaerobic 2 (t = 4.272, p = 0.002) exercise time points between the conditions with the higher values seen in the hyperthermic condition (Table 9). All exercise time points were significantly higher than the baseline values ($p < 0.001$) and the recovery values ($p < 0.001$) (Table 9).

Table 8

Mixed Model ANOVA: Rating of Perceived Exertion

Effect	F	df	*p*
Time	71.663	7	<0.001
Condition	14.211	1	0.004
Time*Condition	3.990	7	0.001

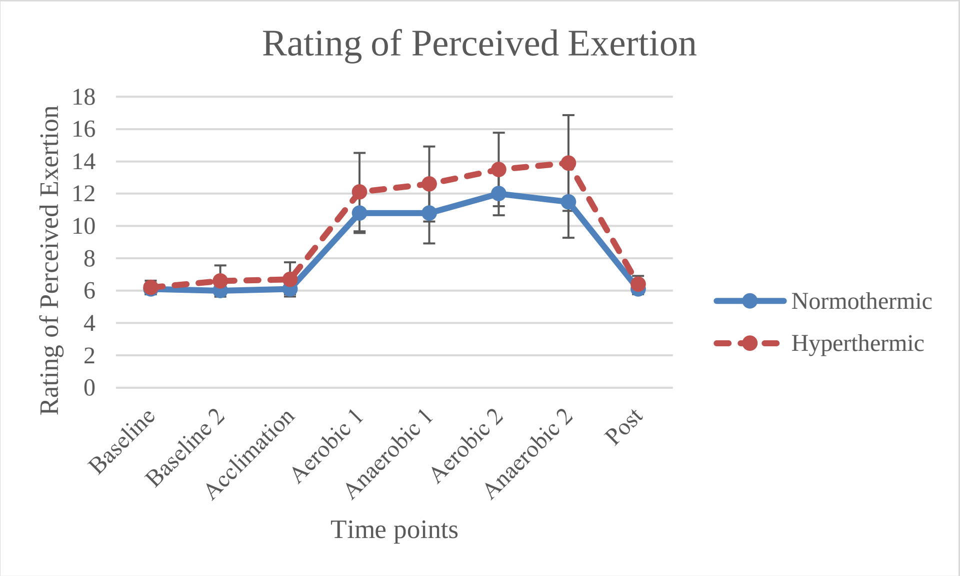

Figure 4. Rating of perceived exertion. Change in RPE over 8-time points in both environmental conditions.

Table 9

RPE Data

	Normothermic	Hyperthermic
Baseline 1	6.100 ± 0.316	6.200 ± 0.422
Baseline 2	6.000 ± 0.000	6.600 ± 0.966
Acclimation	6.100 ± 0.316	6.700 ± 1.059
Aerobic 1	10.800 ± 1.229**	12.100 ± 2.424**
Anaerobic 1	10.800 ± 1.874**	12.600 ± 2.319**
Aerobic 2	12.000 ± 1.333**	13.500 ± 2.273**#
Anaerobic 2	11.500 ± 2.224**	13.900 ± 2.961**#
Post	6.100 ± 0.316	6.400 ± 0.516

Note. Data are mean ± SD.
*$p < 0.05$, significantly higher compared to baseline in both conditions.
**$p < 0.001$, significantly higher compared to baseline in both conditions.
#$p < 0.05$, significantly higher in the hyperthermic condition compared to normothermic condition.
##$p < 0.001$, significantly higher in the hyperthermic condition compared to normothermic condition.
Values presented based on Borg's Rating of Perceived Exertion Scale (6-20).

Hypothesis 2D stated that oxygen consumption (VO_2) in the hyperthermic condition will be higher during exercise. After running a 2-condition x 8 time points ANOVA, the null hypothesis is accepted. There is a significant condition by time interaction (F = 5.561, $p < 0.001$) (Table 10). There is not a significant main effect of condition (F = 1.824, $p = 0.210$) (Table 10). There is a significant main effect of time (F = 50.566, $p < 0.001$) (Table 10). Figure 4 shows these results. Post-hoc analysis demonstrated a statistically significant difference between all resting and exercise time points ($p < 0.001$) (Table 11). The increase in VO_2 was statistically significant at aerobic 1 compared to baseline ($p = 0.001$) (Table 11). A significant decrease in

VO_2 was seen following anaerobic 1 ($p = 0.021$). Aerobic 2, however, was not statistically significant compared to anaerobic 2 ($p = 0.110$) (Table 11).

Table 10

Mixed Model ANOVA: Oxygen Consumption

Effect	F	df	*p*
Time	50.566	7	<0.001
Condition	1.824	1	0.210
Time*Condition	5.561	7	<0.001

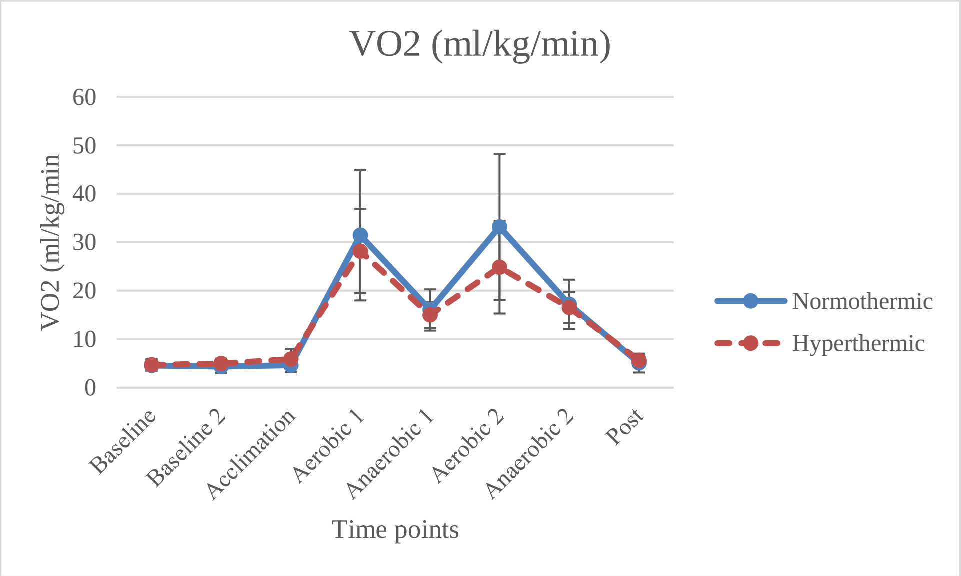

Figure 5. VO_2. Change in VO_2 over 8-time points in both environmental conditions.

Table 11

VO_2 Data

	Normothermic	Hyperthermic
Baseline 1	4.570 ± 1.161	4.700 ± 1.160
Baseline 2	4.360 ± 1.355	4.990 ± 1.014
Acclimation	4.620 ± 1.431	5.910 ± 2.119
Aerobic 1	31.430 ± 13.425**	28.180 ± 8.694**
Anaerobic 1	16.033 ± 4.252**	14.980 ± 2.653**
Aerobic 2	33.180 ± 15.080*	24.850 ± 9.546*
Anaerobic 2	17.190 ± 5.096**	16.520 ± 3.198**
Post	5.075 ± 1.941	5.620 ± 1.398

Note. Data are mean ± SD.
*$p < 0.05$, significantly higher compared to baseline in both conditions.
**$p < 0.001$, significantly higher compared to baseline in both conditions.
#$p < 0.05$, significantly higher in the hyperthermic condition compared to normothermic condition.
##$p < 0.001$, significantly higher in the hyperthermic condition compared to normothermic condition.
Values are presented in milliliters per kilogram of body weight per minute (ml/kg/min).

Hypothesis 2E stated that thermal sensation (TS) in the hyperthermic condition will be higher during exercise. After running a 2-condition x 8 time points ANOVA, the null hypothesis is accepted. There is a significant condition by time interaction (F = 14.561, $p < 0.001$), a significant main effect of condition (F = 112.034, $p < 0.001$) and main effect of time (F = 31.223, $p < 0.001$) (Table 12). These results can be seen in figure 5. Post-hoc analysis shows TS increased significantly from baseline during aerobic 1 ($p = 0.011$), anaerobic 1 ($p = 0.010$), aerobic 2 ($p = 0.003$) and anaerobic 2 ($p = 0.006$) (Table 13). TS was significantly higher in the hyperthermic condition at baseline 1 (t = 3.354, $p = 0.008$), baseline 2 (t = 10.776, $p < 0.001$), acclimation (t = 14.697, $p < 0.001$), aerobic 1 (t = 6.708, $p < 0.001$), anaerobic 1 (t = 4.993, $p = 0.001$), aerobic 2 (t = 5.582, $p < 0.001$), anaerobic 2 (t = 7.965, $p < 0.001$) but was not significantly higher post-exercise (t = 1.00, $p = 0.343$) (Table 13).

Table 12

Mixed Model ANOVA: Thermal Sensation

Effect	F	df	*p*
Time	8.716	7	0.051
Condition	112.034	1	0.000
Time*Condition	9.926	7	0.043

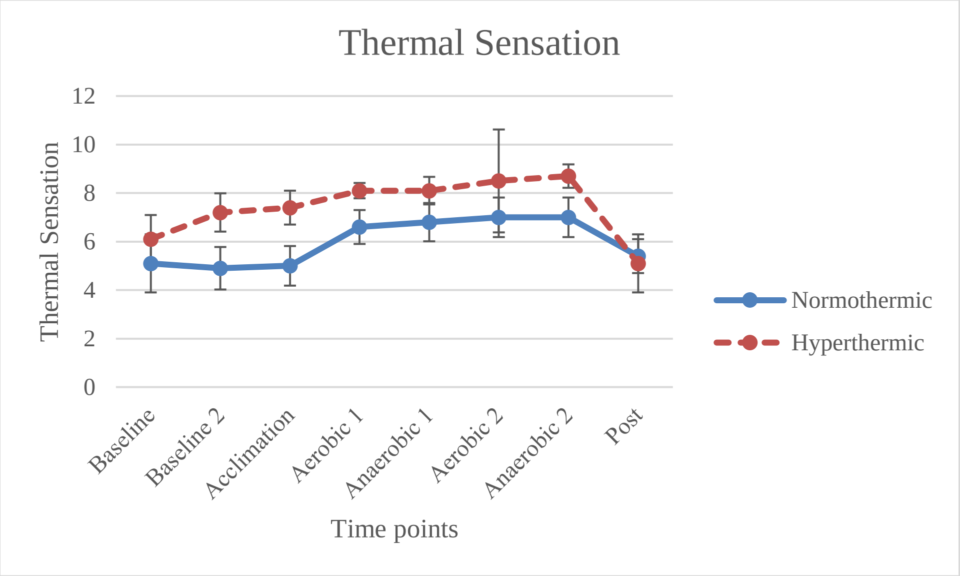

*Figure 6.*Thermal Sensation Scale. Change in thermal sensation over 8-time points in both environmental conditions.

Table 13

TS Data

	Normothermic	Hyperthermic
Baseline 1	5.100 ± 1.197	6.100 ± 0.994#
Baseline 2	4.900 ± 0.876	7.200 ± 0.789##
Acclimation	5.000 ± 0.816	7.400 ± 0.699##
Aerobic 1	6.600 ± 0.699*	8.100 ± 0.316*##
Anaerobic 1	6.800 ± 0.789*	8.100 ± 0.568*#
Aerobic 2	7.000 ± 0.816*	8.500 ± 2.121*##
Anaerobic 2	7.000 ± 0.816*	8.700 ± 0.483*##
Post	5.400 ± 0.699	5.100 ± 1.197

Note. Data are mean ± SD.
*$p < 0.05$, significantly higher compared to baseline in both conditions.
**$p < 0.001$, significantly higher compared to baseline in both conditions.
#$p < 0.05$, significantly higher in the hyperthermic condition compared to normothermic condition.
##$p < 0.001$, significantly higher in the hyperthermic condition compared to normothermic condition.
Values are presented from the Thermal Sensation Scale (1-9).

Hypothesis 2F stated that core temperature in the hyperthermic condition will be higher during exercise. After running a 2-condition x 8 time points ANOVA, the null hypothesis is accepted. There is not a statistically significant condition by time interaction (F = 1.859, p = 0.092) (Table 14). There is a statistically significant main effect of condition (F = 6.298, p = 0.033) and main effect of time (F = 8.996, $p < 0.001$) (Table 14). These results can be seen in Figure 6. Post-hoc analysis demonstrates a statistically significant increase in CT at the first anaerobic bout when compared to acclimation (p = 0.012), a significant increase from acclimation was also seen in aerobic 2 (p = 0.001) this was accompanied by a significant decrease following exercise (*p* = 0.003) (Table 15). CT was significantly higher in the hyperthermic condition following exercise (t = 4.444, *p* = 0.002) (Table 15).

Table 14

Mixed Model ANOVA: Core Temperature

Effect	F	df	*p*
Time	8.996	7	<0.001
Condition	6.298	1	0.033
Time*Condition	1.859	7	0.092

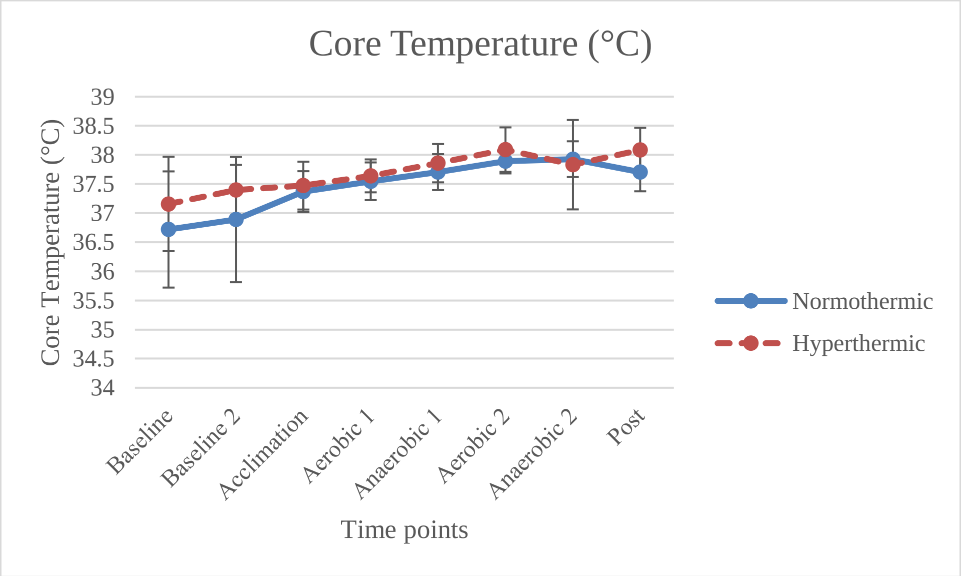

Figure 7. Core temperature (°F). Change in core temperature over 8-time points in both environmental conditions.

Table 15

CT Data

	Normothermic	Hyperthermic
Baseline 1	36.719 ± 0.998	37.157 ± 0.811
Baseline 2	36.888 ± 1.076	37.394 ± 0.434
Acclimation	37.369 ± 0.351	37.473 ± 0.411
Aerobic 1	37.547 ± 0.324	37.64 ± 0.283
Anaerobic 1	37.704 ± 0.309*	37.858 ± 0.329*
Aerobic 2	37.891 ± 0.209*	38.091 ± 0.382*
Anaerobic 2	37.927 ± 0.307	37.832 ± 0.768
Post	37.707 ± 0.332*	38.082 ± 0.383*#

Note. Data are mean ± SD.
*$p < 0.05$, significantly higher compared to acclimation in both conditions.
**$p < 0.001$, significantly higher compared to acclimation in both conditions.
#$p < 0.05$, significantly higher in the hyperthermic condition compared to the normothermic condition.
##$p < 0.001$, significantly higher in the hyperthermic condition compared to the normothermic condition.
Values are presented as degrees, Celsius (°C).

Hypothesis 2G stated that mean skin temperature in the hyperthermic condition will be higher. After running a 2-condition x 8 time points ANOVA, the null hypothesis is accepted. There is a significant condition by time interaction (F = 11.999, $p = 0.033$), main effect of condition (F = 20.83, $p = 0.015$) and main effect of time (F = 442.304, $p < 0.001$) (Table 16). These results can be seen in Figure 7. Post-hoc analysis demonstrates a statistically significant difference between baseline and exercise time points ($p < 0.001$) (Table 17). MST is significantly higher at aerobic 1 ($p < 0.001$), anaerobic 1 ($p < 0.001$), aerobic 2 ($p < 0.001$) and anaerobic 2 ($p = 0.001$) when compared with baseline 1. MST was significantly higher in the hyperthermic condition at baseline 1 (t = 6.318, $p < 0.001$), baseline 2 (t = 14.666, $p < 0.001$), acclimation (t = 22.725, $p < 0.001$), aerobic 1 (t = 19.687, $p < 0.001$), anaerobic 1 (t = 12.061, $p < 0.001$), aerobic 2 (t = 15.175, $p < 0.001$), anaerobic 2 (t = 6.653, $p < 0.001$) and post-exercise (t = 7.050, $p < 0.001$) (Table 17).

Table 16

Mixed Model ANOVA: Mean Skin Temperature

Effect	F	df	*p*
Time	442.304	7	< 0.001
Condition	20.83	1	0.015
Time*Condition	11.999	7	0.033

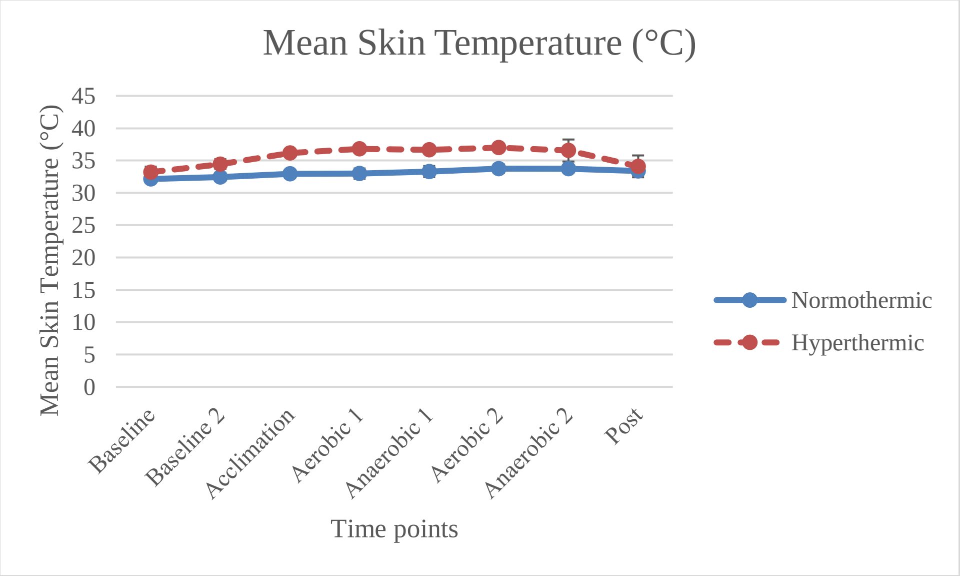

Figure 8. Mean skin temperature (°C). Change in MST over 8-time points in both environmental conditions.

Table 17

MST Data

	Normothermic	Hyperthermic
Baseline 1	32.153 ± 0.541	33.204 ± 0.862##
Baseline 2	32.471 ± 0.651**	34.452 ± 0.760**##
Acclimation	32.92 ± 0.601**	36.138 ± 0.501**##
Aerobic 1	32.983 ± 0.799 **	36.817 ± 0.365**##
Anaerobic 1	33.303 ± 0.853**	36.654 ± 0.327**##
Aerobic 2	33.751 ± 0.659**	36.992 ± 0.415**##
Anaerobic 2	33.719 ± 0.593*	36.555 ± 1.702*##
Post	33.394 ± 0.656	34.106 ± 1.688##

Note. Data are mean ± SD.
*$p < 0.05$, significantly higher compared to baseline in both conditions.
**$p < 0.001$, significantly higher compared to baseline in both conditions.
#$p < 0.05$, significantly higher in the hyperthermic condition compared to normothermic condition.
##$p < 0.001$, significantly higher in the hyperthermic condition compared to normothermic condition.
Values are presented as degrees, Celsius (°C).

Hypothesis 2H stated that mean body temperature in the hyperthermic condition will be higher during exercise. After running a 2-condition x 8 time points ANOVA, the null hypothesis is accepted. There is a statistically significant condition by time interaction (F = 18.675, $p < 0.001$) (Table 18). There is a significant main effect of condition (F = 442.304, $p < 0.001$) and main effect of time (F = 37.021, $p < 0.001$) (Table 18). These results can be seen in Table 7. Figure 9 illustrates the relationship between the normothermic and hyperthermic conditions. Post-hoc analysis demonstrates a statistically significant difference between baseline and exercise time points ($p < 0.001$) (Table 19). MBT is significantly higher at aerobic 1 ($p = 0.00$), anaerobic 1 ($p = 0.001$), aerobic 2 ($p < 0.001$) and anaerobic 2 ($p = 0.006$) when compared with baseline 1. Baseline 2 and acclimation are also significantly higher than baseline 1 as well ($p = 0.008$, $p = 0.002$, respectively). MBT was significantly higher in the hyperthermic condition at baseline 1 (t = 5.767, $p < 0.001$), baseline 2 (t = 8.172, $p < 0.001$), acclimation (t = 12.752, $p < 0.001$), aerobic 1 (t = 19.153, $p < 0.001$), anaerobic 1 (t = 12.978, $p < 0.001$), aerobic 2 (t = 16.404, $p < 0.001$), anaerobic 2 (t = 4.294, $p = 0.002$) and post-exercise (t = 2.748, $p = 0.023$) (Table 19).

Table 18

Mixed Model ANOVA: Mean Body Temperature

Effect	F	df	*p*
Time	37.021	7	<0.001
Condition	442.304	1	<0.001
Time*Condition	18.675	7	<0.001

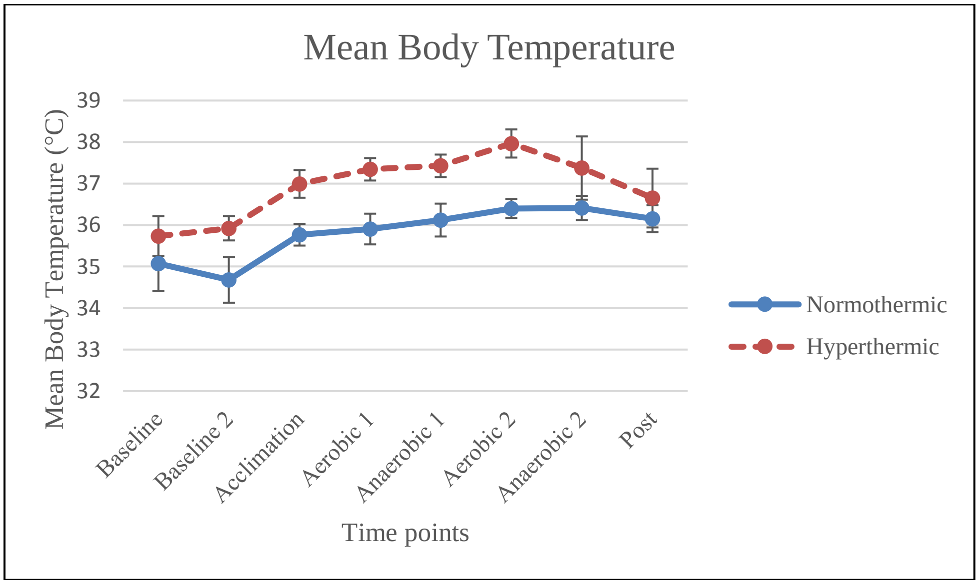

Figure 9. Mean body temperature (°C). Change in MBT over 8-time points in both environmental conditions.

Table 19

MBT Data

	Normothermic	Hyperthermic
Baseline 1	35.075 ± 0.659	35.734 ± 0.480##
Baseline 2	34.68 ± 0.550*	35.923 ± 0.293*##
Acclimation	35.768 ± 0.262*	36.992 ± 0.334*##
Aerobic 1	35.904 ± 0.370*	37.343 ± 0.270*##
Anaerobic 1	36.12 ± 0.396*	37.427 ± 0.271*##
Aerobic 2	36.401 ± 0.229**	37.965 ± 0.339**##
Anaerobic 2	36.412 ± 0.291*	37.373 ± 0.762*#
Post	36.154 ± 0.325*	36.65 ± 0.708*#

Note. Data are mean ± SD.
*$p < 0.05$, significantly higher compared to baseline in both conditions.
**$p < 0.001$, significantly higher compared to baseline in both conditions.
#$p < 0.05$, significantly higher in the hyperthermic condition compared to normothermic condition.
##$p < 0.001$, significantly higher in the hyperthermic condition compared to normothermic condition.
Values are presented as degrees, Celsius (°C).

Hypothesis 2I stated that RER in the hyperthermic condition will be higher. After running a 2-condition x 8 time points ANOVA, the null hypothesis is accepted. There is a statistically significant condition by time interaction (F = 7.643, $p < 0.001$), a significant main effect of condition (F = 10.318, $p = 0.012$) and main effect of time (F = 9.192, $p < 0.001$) (Table 20). Figure 10 shows the relationship between the normothermic and hyperthermic conditions. Post-hoc analysis reveals that “Aerobic 1” is significantly higher than all other time points ($p = 0.001$) (Table 21). The normothermic condition was statistically significantly higher at time points aerobic 1 (t = 2.901, *p* = 0.020), anaerobic 1 (t = 2.919, *p* = 0.019), aerobic 2 (t = 4.639, *p* = 0.002), anaerobic 2 (t = 3.452, *p* = 0.009) and post (t = 3.461, *p* = 0.007). (Table 21).

Table 20

Mixed Model ANOVA: RER

Effect	F	df	*p*
Time	9.912	7	<0.001
Condition	10.318	1	0.012
Time*Condition	7.643	7	<0.001

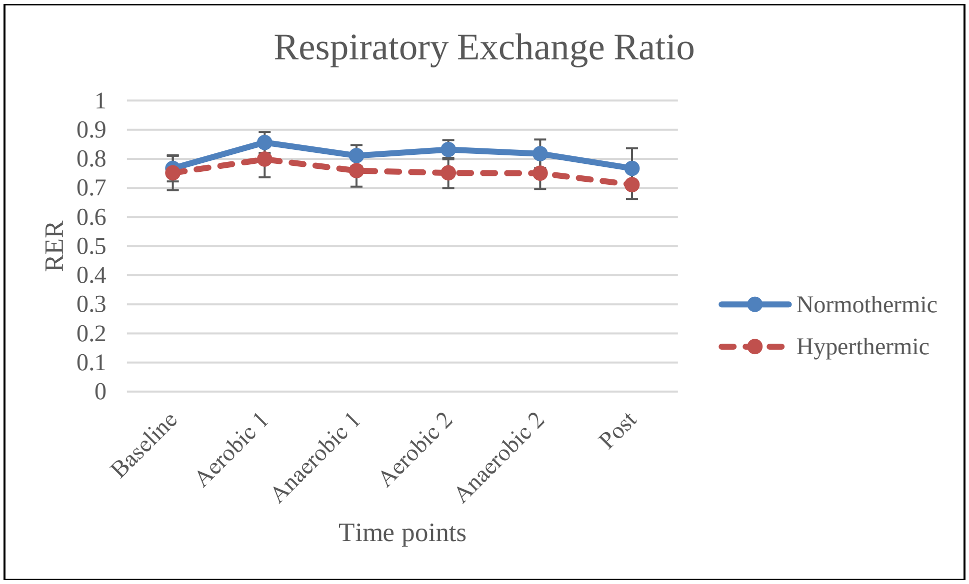

Figure 10. Respiratory exchange ratio. Change in RER over 8-time points in both environmental conditions.

Table 21

RER Data

	Normothermic	Hyperthermic
Baseline 1	0.767 ± 0.045	0.751 ± 0.059
Aerobic 1	0.856 ± 0.036*#	0.798 ± 0.062
Anaerobic 1	0.811 ± 0.036#	0.759 ± 0.055
Aerobic 2	0.831 ± 0.033#	0.751 ± 0.052
Anaerobic 2	0.817 ± 0.049#	0.750 ± 0.054
Post	0.767 ± 0.069#	0.711 ± 0.049

Note. Data are mean ± SD.
*$p < 0.05$, significantly higher compared to baseline in both conditions.
**$p < 0.001$, significantly higher compared to baseline in both conditions.
#$p < 0.05$, significantly higher in the normothermic condition compared to the hyperthermic condition.
##$p < 0.001$, significantly higher in the normothermic condition compared to the hyperthermic condition.

CHAPTER V

DISCUSSION/CONCLUSION

Discussion

Upon reviewing the results of this study, it is clear that a hyperthermic environment will have a significant impact physiological responses to exercise. All the participants who finished the study were able to successfully complete the simulated occupational task. This contradicts a study conducted on firefighters performing a simulated rescue mission. Sixteen firefighters performed the same task under different conditions and most had two or less successful trials of eight attempts (Richmond, 2008). In the present study subjects were held to maintaining a 70%-80% range based on their maximal heart rate tested in the initial familiarization session. In the event that a subject exceeded their target heart rate range for more than one minute the intensity was lowered by decreasing the treadmill grade by 2.5% or decreasing the treadmill speed by an initial 0.3mph and 0.5mph thereafter. The desired range was maintained through the duration of that aerobic bout and intensity was reset at the beginning of the next bout and adjusted again as needed. Monitoring intensity might be the reason for the subject’s ability to complete the experimental protocol because it was based off their level of physical fitness. This demonstrates that a 70%-80% of heart rate maximum is a manageable intensity for EMT students.

Blood lactate accumulation demonstrated a significant main effect of time but not condition. Increases in blood lactate were seen during acclimation in both conditions as well as with the onset of the first aerobic exercise bout. Following the aerobic exercise bout a decrease in blood lactate is seen during the anaerobic sandbag lift. The second aerobic exercise bout causes another increase that was maintained throughout the rest of the protocol in both conditions, with a slight decrease following the 10-minute rest period. This aligns with results found by Parkin et. al (1999), who observed no significant difference between intramuscular lactate concentration and a hot environment and a normal environment in endurance athletes training to fatigue. De Barros et. al (2011) found that heat had a significant impact on blood lactate accumulation in steady state exercise. They examined the impact of heat on a subject's ability to stay below lactate threshold at the same intensity. Evidence on blood lactate accumulation and environmental extremes is still unclear. There are inconsistent exercise types and durations in all of these studies that could be impacting the varying results. When a person is working at a lower intensity they are able to remove blood lactate faster than it accumulates. The intensity at which someone can clear blood lactate as quickly as they are producing it is directly related to fitness level. Other factors, such as environment, play a role as well which could explain the inconsistent results between these studies (Kenney, 2012). EMTs responding to an emergency situation do not get to determine or change the intensity at which they work. Working at a higher intensity could lead to faster blood lactate accumulation and increased fatigue making it much more difficult to accomplish a task.

It is expected that heart rate, oxygen consumption, MAP, and RPE will continue to rise as intensity increases (Kenney, 2012). In the present study we maintained the intensity of 70%-80% heart rate max through monitoring heart rate and adjusting treadmill incline and speed as needed. All subjects needed the intensity lowered in the hyperthermic conditions. Some subjects required as many as 4 intensity decreases to stay in their target heart rate range. Subjects that were considered more aerobically fit based on their VO_2max test did not need the intensity adjusted in the normothermic condition. Their less fit counterparts needed multiple adjustments of intensity under both environmental conditions. It is a minimum requirement that first responders and more specifically EMTs can lift 50 lb. on their own. For that reason, regardless of level of fitness the present study utilized a sandbag weighing 50 lb. for the anaerobic bout of exercise. EMTs are sent into a variety of settings to deal with a variety of emergencies. This minimum fitness requirement is essential in their ability to work. A significant main effect of time was seen in heart rate, RPE, MAP, and oxygen consumption. In these variables significant increases from baseline were seen. Oxygen consumption was higher during the aerobic exercise and lower during the anaerobic exercise which is an expected response. The exercise bouts in this study correlate well with the time of exertion seen in a study done by Gamble et. al (1991). Gamble looked at the energy expenditure required to complete a variety of occupational and emergency tasks among ambulance workers in Belfast. On average, these tasks lasted between 8 and 11 minutes with an energy demand of approximately 60% of VO_2max or higher (Gamble, 1991). The total exercise time in the present study was 30 minutes. While one emergency situation may only require 8-11 minutes of exertion the average shift of an EMT is 12-24 hours (Cydulka, 1997). Over the course of a shift a first responder is expected to be ready and able to jump into action at any moment. The present study demonstrates a large difference in fitness level between EMT students. Students appeared to be either very fit or very unfit which lead to a large difference in results that can be seen in the raw data. An EMT with a higher level of aerobic and anaerobic fitness could withstand the high intensity work for a longer period of time than their less fit counterparts. Parkin et. al (1999) found that environmental factors effected the length of time trained cyclists could perform a submaximal bout of exercise. The duration of an emergency situation will impact the core temperature, MST, MBT and thermal sensation as these were all found to have a significant main effect of time. The impact seen on physiological responses to exercise in this population could be detrimental to their life saving skills. EMTs would benefit from increasing their fitness levels because they would not see as extreme physiological responses at lower intensities.

Cheuvront et. al found that a hyperthermic environment not only produced a shorter time to fatigue but also a higher skin temperature, core temperature and rating of perceived exertion. These results are similar to what was seen in the present study. Core temperature, rating of perceived exertion and thermal sensation were all seen to be significantly impacted by time in a review by Cheung et. al (2004) as well.

A hyperthermic environment impacted core temperature, MBT, MST, thermal sensation, RPE and heart rate. These findings coincide with those of Parkin et. al (1999) which demonstrated a significant increase in rectal temperature and muscle temperature in cyclists exercising sub maximally in a hot, normal and cold environment. Another study of heat stress demonstrated a significant increase in skin temperature during aerobic exercise. The same study also showed a significantly higher heart rate in a hyperthermic environment (Cheuvront, 2010). Cheuvront et. al also demonstrated a significant difference in VO_2 while exercising in the heat which differs from the results seen in the present study. Body temperature and physiological responses are both significantly effected by the presence or absence of heat.

Rapid increases in core temperature can lead to heat illness or death. In 2012-2013 OSHA reported 13 occupational deaths by heat illness. In most of these cases the worker was outdoors and doing moderate to high intensity work. Therefore it is important to monitor how quickly core temperature increases while performing physical activity in extreme heat. A core temperature of 104°F is considered the level at which heat illness can result. It is important that employees understand the signs and symptoms of heat illness and how to eliminate the risk of it. OSHA encourages workers to find water, rest and shade (Arbury, 2014). Cheung et. al (2004) report that while 104°F is where heat illness commonly begins moderately trained humans will begin to feel the onset of heat-related discomfort at approximately 102°F. This does not say what the situation might be for untrained individuals which means it could be even lower for their trained counterparts. With many studies showing first responders are a generally unfit population this is another important factor to consider when evaluating environmental risks for this population (Thornton, 2014).

These findings confirm that the length of exercise and the environmental condition in which the activity is performed play a significant role in physiological responses. This information is important to first responders because of the highly physical nature of their occupation. Physical fitness level plays a large role in a person's ability to perform an occupational task (Richmond, 2008). The physical demands of first responders cause a high level of energy demand (Gamble, 1991). First responders would benefit in health and fitness interventions to reduce risk factors and increase fitness level. A study implementing educational sessions on exercise basics, nutritional recommendations, cooking classes and physiological impacts of stress along with group exercise classes found favorable increases in fitness level among firefighters in Fairfield, Connecticut (Bjerke, 2011).

Limitations

The inclusion criteria required by this study lead to certain limitations. A final sample size of 10 subjects makes generalizability of the results difficult. Subjects had to be current or recent IUP EMT students with no musculoskeletal injuries in the last six months. They had to complete the first phase of the study, regarding health and behavioral habits to be qualified for the exercise portion of the study. The researchers utilized a sample of convenience that represents only a small rural population. The results from this study are reflective of students studying to become practicing EMS personnel not those in the career. Intensity was decreased if the subject exceeded 80% of their heart rate maximal for more than 1 minute of aerobic exercise for the safety of the subjects. Eliminating that adjustment may have led to more significant results but put the subjects at a higher risk for heat related complications.

Future Implication/Direction of Research

Studies moving forward should evaluate practicing EMTs and inquire in the duration of their career. This type of analyzing risk factors, health status and performance during a simulated occupational task, compared with the length of career could help pinpoint when health status becomes detrimental to the ability to complete work safely. Franke et. al (1994) found that law enforcement officers that were regular exercisers has a significantly decreased risk of cardiovascular disease. With cardiovascular disease being such a significant cause of on-duty deaths among all first responders, future research should start with evaluations of students in their respective field and study the population as their career progresses (Kales, 2007).

Future studies should also evaluate physiological responses in a hypothermic environment performing a simulated occupational stress. Studies have shown that extreme heat and cold both cause increased physiological stress than a normal environment. Cold environments effect the contractibility of the muscle fibers impacting muscular strength. Oxygen demand increases as a result of a cold environment causing an increase in the energy needed to perform a specific task (Horvath, 1981). Research strongly suggests that a fast rise in core temperature can lead to heat illness, injury and death (Cheuvront, 2010). Core temperature displayed a significant change in the present study with acclimation and monitoring. These things are not available in a true emergency setting. It is important that all first responders are made aware of the steps to take to prevent heat illness. Environmental extremes whether hot or cold can produce significant physiological changes that need to be understood.

First responders are subject to extreme environments as well as high intensity exercise conditions. This information should be used to apply physical activity requirements and recommendations to keep first responders active enough to maintain good health without causing injury. Smith et. al (2005) suggest that the physical stress paired with the exhaustion-inducing long shifts can decrease hormone and immune responses in firefighters.

Public safety and the safety of all first responders is dependent on the first responder's ability to complete the task at hand safely and efficiently. Exercise programming should be made readily available to all first responders. Physical fitness guidelines should be established to help reduce on-duty deaths related to cardiovascular disease risk factors and a lack of physical fitness. A primary change that should be implied is education on the risks of environmental factors and cardiovascular disease. Increased physical fitness levels can improve response to environmental extremes while reducing disease risk so steps should be taken to begin physical activity programs in first responder stations. An eventual goal of physical activity requirements for all practicing first responders could help drastically reduce the negative results from unfitness in first responders.

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Appendix A

Informed Consent

INFORMED CONSENT

You are invited to participate in this research study. The following information is provided in order to help you to make an informed decision whether or not to participate. If you have any questions please do not hesitate to ask. You are eligible to participate because you are a student between the ages of 18-43 years of age in the Institute for Rural Health and Safety Emergency Medical Technician Certificate Program at Indiana University of Pennsylvania (IUP) and have completed a Health Habits Questionnaire during Phase I of the current study.

The purpose of this study is to examine health risk and behaviors among students enrolled in the Emergency Medical Technician Certification Program. The information gained from this study may help us to better understand the health risks that may or may not predispose an individual to perform poorly under occupationally stressful scenarios. Participation in phase two of this study will require approximately 240 minutes of your time and is not considered a part of the EMT training program. Phase two involves three separate visits to the Center for Sports Science Research and Education in Zink Hall. Participation or non-participation will not affect your grade in this or any other course. Your instructor will not know who did/did not participate in this study. Your participation in this study is voluntary.

Visit 1 is a familiarization session. Medical history will be obtained and review by the principal investigator. The subject will have resting values recorded for heart rate and blood pressure, followed by height and body composition. During this initial visit, participants will also familiarize with a cognitive computer battery, to control for a learning effect during the subsequent testing session. Cognitive testing consists of the following;

Cognitive function tests will be assessed with Automated Neuropsychological Assessment Metrics-4th Edition (ANAM4). ANAM4 is a computerized cognitive test battery first developed by the Department of Defense with subtests designed to assess a variety of cognitive domains. Specific subtests utilized for this study include the Running Memory Continuous Performance Task (RMCPT), Stroop Color Word Test (SCWT), and Mood State.

RMCPT assesses attention, concentration, and working memory. Single characters are presented on the display in rapid sequence. The user presses designated buttons to indicate if the displayed character matches or does not match the preceding character.

SCWT assesses processing speed, selective attention, interference, and executive functioning. The SCWT consists of three 45-s tests. The first test involves pressing a corresponding key for each word (i.e., 1 for red, 2 for green, 3 for blue).

The Stroop Color Word Test requires pressing the corresponding key based on color. A series of colors including red, green or blue are presented on the screen. In the final test, a series of words (red, green, blue) are presented in a color that does not match the name of the color displayed by the word. The participants are required to press the response key assigned to color.

Mood state test will be assessed with Automated Neuropsychological Assessment Metrics-4th Edition (ANAM4). The ANAM4 mood state is designed to assess seven categories of mood; anger, anxiety, depression, fatigue, happiness, restlessness, and vigor. Specifically, through the use of a laptop, 42 words expressing various emotions were presented to the subject and they are simply instructed to choose a number between 0 and 6; 0 representing "Not at all" and 6 being "Very Much" for each emotion presented. These emotions are associated with the seven categories of mood state.

Completion of the familiarization of the cognitive test will be followed by a maximal graded exercise test. During this test the subject will be asked to walk at 3.3mph starting at 0% grade and increasing by 2.5% every two minutes until the subject can no longer continue or the principal investigator believes a maximal effort has been reached. This concludes visit 1, which will last about 60 minutes.

Session 1 and 2 involve the simulated occupational stress scenario, outlined as follows.

Participants will come into the Center for Sports Science Research and Education fasted for at least 3 hours prior to participation. This fast is in place to control for substrate utilization and any performance or ergogenic benefit that may be present resulting from consumption of caffeine or other known stimulants. Once in the Center for Sports Science Research and Education, researchers will assess resting heart rate, blood pressure, and blood lactate accumulation. Following these assessments, participants will go through a testing battery of cognitive function, motor performance, and executive function.

After all resting measurements are recorded, participants will undergo a nude body weight to monitor fluid loss and urine specific gravity to assess hydration status. Skin thermistors will be applied in three different locations to record skin temperature. The participant will be moved into an

environmental chamber, either at a temperature of 100°F, 60-70% relative humidity or normal room temperature of 70°F, 10-20% relative humidity. While in a seated position, heart rate, blood pressure, blood lactate accumulation, motor performance, and cognitive/executive function will be re-assessed. Following 30 minutes of acclimation values for heart rate, blood pressure, blood lactate accumulation, and the cognitive battery will be repeated. The participant will then begin wearing the Hans-Rudolph mouthpiece and headset to begin recording oxygen consumption. The simulated occupational task will consist of 10 minutes walking on the treadmill at an intensity of 70%-75% of their maximum heart rate that was established from the familiarization session. Following the treadmill walk heart rate, blood lactate accumulation and blood pressure will be recorded again. Next, subjects will be asked to lift a 50lb sandbag from the ground to a table (72inx28.5in) for 5 minutes. A total of 15 lifts will be performed, giving the participant10 seconds to bring the sandbag to the table and 10 seconds to place the sandbag back down to the floor. Following the 5 minutes of lifting, heart rate, blood pressure and blood lactate accumulation will be measured again. The participant will then repeat those actions for a second time. A second 10-minute walk on the treadmill followed by reassessment of heart rate, blood pressure, and blood lactate accumulation. A second set of 5 minutes of sandbag lift. Immediately following the second lifting session, blood pressure and blood lactate accumulation will be reassessed. The participant will then undergo a passive cool down outside of the chamber for 10 minutes and blood lactate accumulation, blood pressure and heart rate will be recorded. The cognitive battery will be reassessed. After the cool down values are recorded, the participant's nude body weight will be measured to assess weight loss, and urine specific gravity will assess hydration changes during the session. Nude body weight will be performed in a private bathroom with a male researcher for male participants and a female researcher for female participants. Monitoring of the participant's heart rate will continue during a cool down of their choice either passive, treadmill walking, or cycling, until they return to a heart rate 20 bpm above the initial resting value.

This concludes Sessions 1 and 2, which will last about 90 minutes. At the conclusion of this session, all participants will be compensated $50 in the form of an Amazon gift card.

You are free to decide not to participate in this study or to withdraw at any time without adversely affecting your relationship with the investigators or IUP. Your decision will not result in any loss of benefits to which you are otherwise entitled. If you choose to participate, you may withdraw at any time by notifying the Project Director or informing the person administering the test. Upon your request to withdraw, all information pertaining to you will be destroyed. If you choose to participate, all information will be held in strict confidence and will have no bearing on your academic standing or services you receive from the University. Your response will be considered only in combination with those from other participants. The information obtained in the study may be published in scientific journals or presented at scientific meetings but your identity will be kept strictly confidential.

If you are willing to participate in phase two of this study, please sign the statement below and take the extra unsigned copy with you. If you choose not to participate, deposit the unsigned copies in the designated box by the door.

Project Director:
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This project has been approved by the Indiana University of Pennsylvania Institutional Review Board for the Protection of Human Subjects (Phone: 724/357-7730).

VOLUNTARY CONSENT FORM:

I have read and understand the information on the form and I consent to volunteer to be a subject in this study. I understand that my responses are completely confidential and that I have the right to withdraw at any time. I have received an unsigned copy of this informed Consent Form to keep in my possession.

Name (PLEASE PRINT):____

Signature:____

Date:________________

Appendix B

Health History

Indiana University of Pennsylvania

Center for Sport Science Research and Education

HEALTH HISTORY

Thank you for participating in the EMT Health Habits Survey: Phase 2 within the Center for Sport Science Research and Education at IUP! We are happy to have you! You may be performing moderate/vigorous exercise as part of this program. Consequently, it is important that we have an accurate assessment of your past and present health status to assure that you have no medical conditions that would make your participation in this program dangerous. Please complete the health history as accurately as you can. This medical history is confidential and will only be seen by Dr. Gerhart and assisting KHSS faculty to determine your qualifications for this study.

Name____ Date____/____/____

Date of Birth____/____/____ Present Age_____yrs

Ethnic Group: ____White

____ African American

____ Hispanic

____ Asian

____ Pacific Islands

____ American Indian

____ Other_____________

HOSPITALIZATIONS AND SURGERIES

If you have ever been hospitalized for an illness or operation, please complete the chart below. Do not include normal pregnancies, childhood tonsillectomy, or broken bones.

YEAR______________

OPERATIONS OR LLNESS

____

____

YEAR______________

OPERATIONS OR ILLNESS

____

____

YEAR______________

OPERATIONS OR ILLNESS

____

____

Are you under long-term treatment for a protracted disease, even if presently not taking medication? [ ] Yes [ ] No

If Yes, explain:____
____
____

MEDICATIONS

Please list all medications that you have taken within the past 8 weeks: (Include prescriptions, vitamins, over-the-counter drugs, nasal sprays, aspirins, birth control pills, etc.)

Check this box [ ] if you have not taken any medication.

MEDICATION________________

REASON FOR TAKING THIS

____

____

MEDICATION________________

REASON FOR TAKING THIS

____

____

MEDICATION________________

REASON FOR TAKING THIS

____

____

ALLERGIES

Please list all allergies you have (include pollen, drugs, alcohol, food, animals, etc.)

Check this box [ ] if you have no allergies.

1.____

2.____

3.____

4.____

When was the last time you were “sick”? (e.g. common cold, flu, fever, etc.)

____

PROBLEMS AND SYMPTOMS

Place an X in the box next to any of the following problems or symptoms that you have had:

<u>General</u>

[ ] Mononucleosis

If yes, when____

[ ] Excessive fatigue

[ ] Recent weight loss while not on a diet

[ ] Recent weight gain

[ ] Thyroid disease

[ ] Fever, chills, night sweats

[ ] Diabetes

[ ] Arthritis

[ ] Sickle Cell Anemia
[ ] Heat exhaustion or heat stroke
[ ] Recent sunburn

PROBLEMS AND SYMPTOMS, continued

Heart and Lungs

[ ] Abnormal chest x-ray
[ ] Pain in chest (persistent and/or exercise related)
[ ] Heart attack
[ ] Coronary artery disease
[ ] High blood pressure
[ ] Rheumatic fever
[ ] Peripheral vascular disease
[ ] Blood clots, inflammation of veins (phelebitis)
[ ] Asthma, emphysema, bronchitis
[ ] Shortness of breath
    [ ] At rest
    [ ] On mild exertion
[ ] Discomfort in chest on exertion
[ ] Palpitation of the heart; skipped or extra beats
[ ] Heart murmur, click
[ ] Other heart trouble
[ ] Lightheadedness or fainting
[ ] Pain in legs when walking
[ ] Swelling of the ankles

[ ] Need to sleep in an elevated position with several pillows

G-U SYSTEM

[ ] Get up at night to urinate frequently

[ ] Frequent thirst

[ ] History of kidney stones, kidney disease

G.I. TRACT

[ ] Eating disorder (e.g. anorexia, bulimia)

[ ] Yellow jaundice

If yes, when____

[ ] Hepatitis

If yes, when____

[ ] Poor appetite

[ ] Frequent indigestion or heartburn

[ ] Tarry (black) stool

[ ] Frequent nausea or vomiting

[ ] Intolerance of fatty foods

[ ] Changes in bowel habits

[ ] Persistent constipation

[ ] Frequent diarrhea

[ ] Rectal bleeding

[ ] Unusually foul smelling or floating stools

[ ] Pancreatitis

Nervous System

[ ] Alcohol problem

[ ] Alcohol use

If yes, how many drinks ingested per week? ___________________

[ ] Frequent or severe headaches

[ ] Stroke

[ ] Attacks of staggering, loss of balance, dizziness

[ ] Persistent or recurrent numbness or tingling of hands or feet

[ ] Episode of difficulty in talking

[ ] Prolonged periods of feeling depressed or “blue”

[ ] Difficulty in concentrating

[ ] Suicidal thoughts

[ ] Have had psychiatric help

Explain any items checked (when, severity, treatment)

____
____
____
____
____
____

Have you ever passed out during or after exertion? YES NO

Do you have a family history of coronary artery disease YES NO

If yes, Who? (Grandparents, parents, siblings, uncles, and aunts)

____
____
____

Are you currently taking supplementation that is considered an ergogenic aid? YES NO

If so, please list supplements

____

____

____

Are there any other reasons not mentioned above that you feel you should not participate in this research study? YES NO

Do you currently smoke cigarettes? YES NO

Do you currently use any smokeless tobacco products? YES NO

Space for Additional Comments:

____

____

____

____

____

____

____

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____

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Appendix C

Familiarization Data Collection Sheet

Session 1

Subject #:________________ Gender:___________ Date:___________

RHR:_________ RBP:_________

Height:______________ Weight:_________ BF%:___________

Stage	**Time**	**Speed**	**% Grade**	**HR**	**RPE**
1	2:00	3.3 mph	0		
2	4:00	3.3 mph	2.5		
3	6:00	3.3 mph	5		
4	8:00	3.3 mph	7.5		
5	10:00	3.3 mph	10		
6	12:00	3.3 mph	12.5		
7	14:00	3.3 mph	15		
8	16:00	3.3 mph	17.5		
9	18:00	3.3 mph	20		
10	20:00	3.3 mph	22.5		
11	22:00	3.3 mph	25		
12	24:00	3.5 mph	25		
13	26:00	3.7 mph	25		
Total Test Time					
Recovery					
2 min					
4 min					

Max HR:_________ Max VO2:_________

70%MHR:________ 75%MHR:_________ 80%MHR:_______ HR Range:___________

Appendix D

Data Collection Sheet

Subject #:___________ Date:_________ Session: 1 2 Environment: Hot Normal

BASELINE: COGBAT

HR:______ BP: _________ BLA: ______ CT: _______ RPE: _________ TSS:_________ VO2: ________

PRE-CHAMBER:

NBW: ___________ USG: ___________

BASELINE 2: COGBAT

HR:______ BP: _________ BLA: ______ CT: _______ RPE: _________ TSS:_________ VO2: ________

ACCLIMATION: COGBAT

HR:______ BP: _________ BLA: ______ CT: _______ RPE: _________ TSS:_________ VO2: ________

AEROBIC: Subject HR Range: % Grade:

Time	HR	RPE	THERMAL SENSATION SCALE	CT	VO2
1					
2					
3					
4					
5					

6					
7					
8					
9					
10					

POST-AEROBIC 1:

HR:______ BP: _________ BLA: ______ CT: _______ RPE: _________ TSS:_________
VO2: ________

POST-ANAEROBIC 1:

HR:______ BP: _________ BLA: ______ CT: _______ RPE: _________ TSS:_________
VO2: ________

EXERCISE: Subject HR Range: % Grade:

Time	HR	RPE	THERMAL SENSATION SCALE	CT	VO2
1					
2					
3					
4					
5					
6					
7					

8					
9					
10					

POST-AEROBIC 2:

HR:______ BP: _________ BLA: ______ CT: _______ RPE: _________ TSS:_________
VO2: ________

POST-ANAEROBIC 2:

HR:______ BP: _________ BLA: ______ CT: _______ RPE: _________ TSS:_________
VO2: ________
EXIT CHAMBER

10 MIN PASSIVE REST: COGBAT

HR:______ BP: _________ BLA: ______ CT: _______ RPE: _________ TSS:_________
VO2: ________

POST-CHAMBER:

NBW: ___________ USG: ___________

ACTIVE RECOVERY OF SUBJECTS CHOICE UNTIL 20 BPM ABOVE RESTING HR

Skin Thermistors	**Calf**	**Thigh**	**Chest**	**Forearm**	**Tricep**	**MBT**
Baseline						
Baseline 2						

Acclimation						
Aerobic 1						
Anaerobic 1						
Aerobic 2						
Anaerobic 2						
Post (10 min rest)						