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Cleveland State University

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EFFECTIVENESS OF THE “DRAGON HEAT POLAR SEAT” IN PREVENTING
HYPERTHERMIC STRESS IN ATHLETES

MICHAEL T. KELLER

Bachelor of Science in Exercise Science
University of Toledo
May 2011

submitted in partial fulfillment of requirements for the degree
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We hereby approve this thesis for
Michael Keller
Candidate for the Master of Education in Exercise Science degree
For the College of Education and Human Services
Department of Health and Human Performance
And the CLEVELAND STATE UNIVERSITY
College of Graduate Studies

Thesis Chairperson, **Dr. Kenneth Sparks**

Department & Date

Thesis Committee Member, **Dr. Kathleen Little**

Department & Date

Thesis Committee Member, **Dr. Emily Kullman**

Department & Date

Associate Dean, **Dr. Jane Zaharias**

Effectiveness of the “Dragon Heat Polar Seat” in Preventing Hyperthermic Stress in
Athletes

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EFFECTIVENESS OF THE “DRAGON HEAT POLAR SEAT” IN PREVENTING HYPERTHERMIC STRESS IN ATHLETES

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ABSTRACT

Background: The body’s ability to dissipate heat depends on environmental conditions of temperature, humidity, and air movement. An athlete’s conditioning and acclimation to heat greatly improves performance in hot conditions. However, even then athletes can experience heat related problems such as heat cramps, heat exhaustion, and even heat stroke. **Purpose:** The purpose of this study was to determine the effectiveness of the “Dragon Heat Polar Seat” in preventing hyperthermia in athletes competing in hot, humid climates. **Methods:** Ten healthy active participants (5 males; 5 females) were required to complete three sessions that consisted of a VO₂max test, a treatment run and control run. During the treatment and control run, in a counterbalanced design, the subject exercised in an environmental chamber (86.2°F; 35%relative humidity (RH)) for 53min at 80% VO₂max. The subjects ran for 5 minutes on a motorized treadmill followed by 3 minutes of rest and either sat on a cooling bench during the rest periods for the treatment run, or sat on the bench with no cooling during the rest periods in the control run. Each subject completed six repetitions of 5 minutes running and 3 minutes resting during each trial. **Results:** There were no statistically significant differences in core temperature, heart rate, VO₂, rate of perceived exertion lactic acid accumulation or sweat loss ($p>.05$). There were noticeable differences in performance when using the treatment protocol especially the on RPE, which was lower. Subjects stated that the

exercise felt easier and their body felt recharged after the cooling treatment during the rest period. **Conclusion:** Although not significant, the “Dragon Heat Polar Seat” appeared to show promise as a cooling technique during exercise in hot, humid climates.

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CHAPTER I

INTRODUCTION

The body's ability to dissipate heat depends on environmental conditions of temperature, humidity, and air movement. The athlete's conditioning and acclimation to heat greatly improves performance in hot conditions. Even then, athletes can experience heat related problems such as heat cramps, heat exhaustion, and even heat stroke. Exercise in the heat increases core body temperature and can lead to heat stroke or decreased performance. Heat stroke is defined as a life-threatening illness when the body fails to regulate the core temperature which increases above 104°F while other medical conditions are coinciding from this situation.¹ The body will try to sustain exercise by sending blood to both the muscle, along with the skin and periphery which

work to regulate core body temperature.² Heat exhaustion and heat cramps are the other two conditions associated with the exercising in the heat. Heat exhaustion elicits symptoms of heavy sweating and a rapid pulse.² Heat cramps, are defined as the mildest condition associated with exercise in the heat where athletes will exhibit involuntary muscle spasms that can be quite painful. These spasms are typically seen in the lower limbs and are due to inadequate fluid intake while exercising. Athletes competing in the summer in hot, humid conditions are at increased risk of heat illness. The hypothalamus is a structure in the brain that controls body temperature. While exercising, the hypothalamus sends information to the periphery to promote sweating and regulate the mechanical function of the body.³ When athletes acclimate to exercise in hot conditions, the hypothalamus sends signals to increase sweat production and promote cooling of the body through evaporation.

Athletes need to avoid heat-related injuries and unforeseen deaths that can result from exercising or competing in the heat.⁴ Heat related deaths in the last 20 years have increased to over three deaths per year in football alone.⁴ Football teams have used cold or ice water bath immersion for players that have become hyperthermic because of its effectiveness in treating heat stroke.⁵ Players also use the ice baths as a means to recover quicker after a long practice in the heat. Deaths and instances of heat illness can be reduced or prevented if proper education and improved technology can be used to help decrease body temperature in hyperthermic conditions. The literature reveals that precooling athletes prior to athletic events allows for greater endurance compared to not cooling.⁶

Multiple products have been evaluated to help prevent hyperthermia and advance precooling such as cold baths, mist fans, and specific types of clothing.⁷ These products and techniques help in delaying the onset of hyperthermia so athletes can excel during competition. Multiple studies have been completed to assess the physiological advantage that can be gained from using these products and they all seem to have similar effects.

The “Dragon Heat Polar Seat” (Reliable Construction Heaters, Cleveland, OH) (Appendix A) is designed to help cool the body in hot environments while allowing for increased recovery and performance. The cooling bench blows constant cold air onto the athlete. The cooling of the external body parts or clothing of the athlete is purposed to help control core temperature. A product developed in Australia was used as a cooling jacket and combined with proper hydration status, allowed cyclists and rowers to perform at a higher level for longer periods of time.⁸ The advantage of the cooling bench over the cooling jacket is that the athlete can wear comfortable clothing and the bench stays at a constant flow to air on the back both cooling the core temperature and the clothing of the athlete. Team sports such as football, baseball, basketball, soccer, rugby, lacrosse, and tennis can use the “Dragon Heat Polar Seat” to cool the body during breaks. Heat and humidity does not allow for some individuals to perform optimally due to increased core temperature and lack of hydration. The “Dragon Heat Polar Seat” could revolutionize both precooling and cooling of athletes during team sports after long practices or competitions in the heat and humidity. The “Dragon Heat Polar Seat”

combined with proper hydration during competitions may elicit prolonged performance and less stress on the body in extremely hot and humid environments.

Purpose of Study

The purpose of this study was to determine the effectiveness of the “Dragon Heat Polar Seat” in preventing hyperthermia in athletes running in a hot, humid environment.

Significance of the Study

The “Dragon Heat Polar Seat” could be a revolutionary product for team sports and even some individual sports such as tennis. The product could potentially decrease core body temperature and speed recovery in athletes.

Hypothesis

It was hypothesized that there will be lower core temperature, energy expenditure, lactic acid accumulation, rate of perceived exertion, heart rate and sweat loss when using the Dragon Heat Polar Seat during intermittent activity in the heat compared to not using the Dragon Heat Polar Seat.

Independent Variable

The “Dragon Heat Polar Seat” bench

Dependent Variables

Oxygen Consumption (ml/kg/min)

Blood Lactate (mmol)

Core Temperature (°C)

Heart Rate (bpm)

Borg Rate of Perceived Exertion (6-20)

Sweat Loss (PreWt – PostWt)

CHAPTER II

LITERATURE REVIEW

The literature on athletes and performance in the heat is immense. Wendt et al.⁹ reviewed research on the way the body is affected by heat and ways in which athletes can use different interventions to fight against hyperthermia and other related heat illnesses associated with hyperthermia. Athletes competing in hot environments consistently show decreased performance. During heat stress, the body releases energy as heat so it can maintain multiple physiological functions. Types of heat loss can include radiation, conduction, convection, and evaporation. However, environmental conditions can greatly impact the effectiveness of heat loss, with hot and humid conditions seriously diminishing the body's ability to dissipate heat. Different interventions have been used for thermoregulation including hyperhydration, clothing, and heat

acclimation. Whole body cooling techniques have also been suggested as an effective way to recover after exercise and precooling the body allows for a longer period of high performance by slowing the rise in metabolic heat production.⁹

2.1 Cooling Technique Studies

Barwood et al.⁷ compared different post exercise cooling techniques during hot and humid conditions. Nine male subjects (age= 22 ± 3 yrs) completed a self-paced exercise bout in hot (31.2°C) and humid (70%RH) conditions until reaching a core body temperature of 38.5°C , at which time they sat in front of fans for 30 minutes while their core temperature was recorded. The technique used in the study was effective in reducing core temperature. The conclusion of the study was that multiple interventions (Hand immersion, cooled clothing, and fanning) can be used but the authors noted that a full body fan was the most effective source of cooling before, during and after exercise.⁷

Leicht et al.¹⁰ assessed field-based techniques of cooling used in sports. This study was one of the first that measured heart rate variability during post exercise cool down. The purpose was to examine heart rate variability in men during certain field-based procedures for hyperthermia. Eleven healthy, males (age= 23.5 ± 2.3 yrs) volunteered. The subjects performed three sessions of running on a motorized treadmill in a climate-controlled chamber set at $34.2 \pm 0.5^{\circ}\text{C}$ and $62.3 \pm 3.1\%$ RH. Once core body temperature reached 40°C , the subjects began a cooling technique. This resulted in decreases in core temperature in the following interventions; cold saline infusion, ice

packs, industrial fan cooling with water spray and lying supine with only bike shorts on. The cold saline infusion showed significantly increased heart rates when being injected but allowed for the greatest decrease in core temperature. The conclusion was that different cooling techniques affected the heart rate variability.¹⁰

2.2 Precooling Studies

Duffield and Marino¹¹ explored the effects of precooling in athletes that perform in warm conditions. They specifically chose athletes that sprint and use maximum bouts of energy multiple times during a competition. The purpose was to determine if using an ice vest or taking an ice bath was a more effective way of precooling. Nine moderately trained male rugby players completed an intermittent sprint protocol that lasted 30 minutes and repeated for two total sessions. The subjects ran at maximal effort for 15 meters and then ran into a mat simulating a hit by an opponent. 15 minutes prior to the exercise, the subjects completed the precooling intervention, then again during warm up, and during the 10 minute break. It was concluded that neither the ice vest nor the ice bath were significant methods of increasing sprint performance. They further elaborated that precooling should not just be done before the game; it should be done continuously until the start of competition to ensure that the best results are gained.¹¹

Burdon et al.⁶ and Brade et al.¹² assessed the effectiveness of ice slushy ingestion and exercise performance in the heat. Brade et al.¹² specifically analyzed the combination of an ice jacket and ice slushy ingestion of repeated sprint performance. Ten active males (age= 22 ± 3yrs) participated in the study. The subjects had to

complete 20 laps of sprinting after precooling with the jacket and slushy. . Brade et al.¹² went on to discuss that the combination of precooling techniques done prior to the sprints neither helped nor hurt the subject's performance.

Burdon et al.⁶ looked at whether there were sensory factors associated to the ice slushy and if there was an ergogenic effect on endurance events. Ten active males (age= 30.1 ± 7.0 yrs) completed the study. They had to cycle at a steady state for 90min then complete a time trial, while every 15-minutes the subjects consumed ice slushy or room temperature water. Both researches found that there was a decrease in core temperature with the ice slush drink during precooling. Burdon et al.⁶ finally explained that although the subjects only showed development in RPE and thermal comfort but showed that a cold stimulus in the mouth will give a sensory effect of feeling colder. The results had conflicting data compared to Brade et al.¹² but show different strategies to precooling and effecting performance.^{6 12}

Minett et al.¹³ researched the effects of precooling on performance of sprint shuttle running in the heat. Eight male team sport athletes completed a sprint protocol of 10 total sets (2x5) and 6 repetitions of a 15-meter shuttle run. The precooling strategy included an ice water rinsed towel on the head, neck and shoulder area, hands in cold water to the wrist, and an ice vest covering the torso. They found that cooling the athletes for 20 minutes prior to exercise resulted in higher peak sprint times in the heat compared to the control. They concluded that using the different types of precooling techniques showed a suppression of physiological stress that was on the

body during exercise in heat. They recommended 20 minutes of pre-cooling before exercise in the heat.¹³

Price et al.¹⁴ conducted a similar study to that of Minett et al.¹⁵ where they used precooling as a strategy to increase performance. Price et al.³⁴ determined the effects of both precooling and mid exercise cooling in a simulated soccer match. Eight elite female soccer players (age= 24.5 ± 5.1 yrs) completed three sessions of interval running, jogging and walking for two, 45-minute sessions with a 15 minute break. An ice vest was used and the core and skin temperature were measured. They found that wearing the ice vests both before the game and during the 15-minute rest period, they reduced the risk of thermal strain and injury. Finally, they found that these strategies of wearing the vest worked but further research is needed to determine the effect of VO_2 and muscle temperature.¹⁴

Hasegawa et al.¹⁵ used the same concept as Price et al.¹⁴ but applied a cooling jacket and assessed the subjects on a bicycle ergometer. Nine untrained male subjects (age= 22.1 ± 0.6 yrs) cycled at 60% VO_2max for 60 minutes followed by pedaling to exhaustion under four conditions (control, water intake, cooling jacket, and cooling jacket and water intake). The jacket was made from neoprene material and held eight ice packs over the chest. Combining the hydration and the cooling jacket performance was enhanced and time to exhaustion was increased. They concluded that using the jacket along with hydration decreases the risk of hyperthermic injury.¹⁵

Tyler and Sunderland¹⁶ explored the idea of cooling the neck while exercising in hot environments to override inhibitory signals by the brain compared to if you were not cooling the neck region. The brain sends signals to the body to override movement so the body can cool down and protect against heat stroke or other heat related illnesses. Eight endurance trained males (age= 26 ± 2 yrs) that were not previously acclimated to the heat volunteered for the study. Before the trials began, each subject completed a VO_2max test to determine run pace on motorized treadmill in the environmental chamber. The test included running at 70% VO_2max until exhaustion and was completed two different times, once with the cooling band on the neck and once without. While wearing the neckband, the subjects were able to tolerate exercising in the hot humid environment almost 5 minutes longer. The researchers indicated that cooling the neck regions changed the rate of perceived exertion that they were competing in.¹⁶

2.3 Acclimation Studies

Castle et al.¹⁷ investigated the effects of heat acclimation in sprint athletes. Previous research shows that for heat acclimation to take effect; athletes need to train in the heat for 7 to 14 days prior to an event. This allows the body to train the autonomic nervous system to regulate core temperature, heart rate, etc. more efficiently. Eight moderately trained males who had recently played a college level sport, performed 5 pre-acclimation tests, 10 heat acclimation tests, and 2 post acclimation tests. They used a cycle ergometer to perform a graded exercise protocol

until voluntary exhaustion. During the acclimation stages, the athletes completed cycle ergometer sprint protocols in an environmental chamber. Their results showed no differences in peak power output prior to acclimation of the athletes to the heat. Once the athletes were acclimated to the heat, they showed greater power output in the heat than prior to the heat acclimation. This study refutes the use of precooling in athletes because they showed that their subjects had greater power outputs once they were acclimated to the heat than if they used a precooling method.¹⁷

Fujii et al.¹⁸ researched the effects of heat acclimation on skin vasodilation under heat stress. Heat acclimation, or exercising consistently in hot and humid environments, would allow you to increase performance at higher core temperatures. They hypothesized that short-term heat acclimation would decrease hyperthermia-induced hyperventilation during a submaximal test in the heat. Twenty-one males (age= 23.6 ± 2.3 yrs) were randomly divided into either a control group or heat acclimated group. The experimental group was acclimated to the heat at 58% VO_2max for 6 days prior to the submaximal test. The testing was done on a bike at 25°C and 50%RH; the subjects cycled until the respiratory exchange ratio exceeded 1.1. There was a decrease in ventilation after being acclimated to the heat for 6 days. However, heat acclimation was not affective in increasing the time to hyperthermic induced hyperventilation during the submaximal bike test.¹⁸

Burk et al.¹⁹ determined if heat acclimation had any effect on endurance capacity and prolactin levels in the body. Twenty-two active military males (age= 24.9 ± 3.7 yrs)

completed three exercise tests walking on a motorized treadmill (60% VO_2max until exhaustion in 42°C, in 22°C and after a 10 day acclimation in 42°C). When acclimated to the heat, the blood prolactin level is reduced at submaximal work but not at exhaustion. They concluded that after acclimation the subjects had lower exercise heart rates (~ 7 beats/min) and core temperatures ($\sim 1.2^\circ\text{C}$). The study concluded by showing the difference in performance and how prolactin in males could be used as a heat illness marker or acclimatization marker to determine how the body will handle heat in endurance situations.¹⁹

Kaldur et al.²⁰ assessed the changes in oxidative stress and inflammation when acclimated to the heat. Twenty-one active males (age = 24.9 ± 3.7 yrs) completed an endurance capacity test prior and 10 days after heat acclimation. The subjects were able to sustain the endurance capacity test longer (~ 73 min) after heat acclimation. Oxidative stress markers increased along with inflammation, which can have long-term effects on the body. They concluded that though there are acute effects of acclimation in exercising to exhaustion in the heat, the oxidative stress put on the body is not good for a person of below average fitness level.²⁰

2.4 Hydration Studies

Hasegawa et al.²¹ combined precooling and increased water ingestion on thermoregulation in order to prevent hyperthermia and increase performance. They hypothesized that precooling would lower skin and core temperature, and increased water ingestion would slow temperature increase during exercise. Nine healthy,

untrained males (age= 21.8 ± 0.8 yrs) performed on a cycle ergometer at 26°C, 60%RH at an intensity of 60% VO_2max for 60 minutes during four different sessions (no water intake, precooling, water ingestion at 5 minute intervals, and combination of water ingestion and precooling). Increased water ingestion and precooling techniques combined lowered core body temperature and delayed the increase of core temperature during exercise. They also showed that using either precooling or water ingestion alone during exercise was more effective than the control. They concluded by explaining that using both of these interventions allowed athletes to hydrate and decrease core body temperature to increase performance during their competitions.²¹

Children have been a main focus in the discussion of hyperthermia because their metabolic rates are much higher and the sweat production to allow for recovery and cooling is less effective than that of an adult.²² Young athletes need to acclimate and develop precooling strategies with their coaches and parents as well as hydration that is crucial to preventing heat stress. Bass and Inge²² go on to explain that children that drink sport drinks rather than just water can increase their hydration levels and even the body weight which allowed for faster overall recovery. The authors conclude by expressing advice towards parents and coaches that children should be monitored closely for heat stress signs and take mandatory breaks for fluids.²²

Wilk et al.²³ assessed fluid intake, hydration status, and aerobic performance of adolescent athletes during a hot environment. The focus of the study was to determine if adding flavor to an electrolyte beverage would increase voluntary ingestion of water

to help prevent dehydration. The subjects were eight, 12 to 15 year old males participating in cross-country running. They used a cross over design with the subjects serving as their own control. The subjects completed three sessions of running (5, 15-minute bouts) in temperatures of 30°C and 60-65% RH while consuming different beverages during each trial. They found that fluid rehydration with flavored beverages was more effective at encouraging the young runners to rehydrate and increase length of exercise at proper hydration levels.²³

Bryne et al.²⁴ measured the effectiveness of cold fluid ingestion prior to exercise on decreasing core temperature and increasing performance. Seven male recreational cyclists (age= 21 ± 1.5 yrs) volunteered to participate in the study. The subjects ingested 3-300ml bottles of cold or control fluid over 35-minutes prior to exercise. A 30-minute self paced session on the bicycle ergometer followed. The authors found that there was a greater decrease in rectal temperature when ingesting the cold fluid ($0.41 \pm 0.16^\circ\text{C}$). They also found that the mean power output was greater in the cold fluid group ($275 \pm 27\text{W}$). They concluded that prior to exercise, the ingestion of a cold fluid has precooling applications.²⁴

Tippet et al.²⁵ assessed the alterations in core temperature after a 10 minute break and fluid replacement in tennis players competing in the heat. The subjects were 10 professional female tennis players (age= 23.4 ± 4.5 yrs) all participating in the same tournament played under conditions that according to the American College of Sports Medicine,²⁶ should be cancelled or delayed due to excessive heat and humidity. Baseline

core temperatures were obtained in their 5-minute warm up and immediately before the match began. The 10-minute break during the match showed a significant drop in core temperature due to rehydration of $2.9 \pm 0.9\text{L}$ of water that allowed them to compete at a high level for the second half of the match.²⁵

Vitamin and mineral water has been a product that has gained popularity in the recent past. Deep mineral water is a naturally drilled water from depth of 700m and is primarily enriched with calcium, magnesium and sulfate minerals. Stasiule et al.²⁷ studied the effects of deep mineral water on recovery from dehydrating aerobic exercise in the heat. Nine active women (age= $24 \pm 3.7\text{yrs}$) completed this double blind, placebo crossover study. The subjects ran on a motorized treadmill at 40% Vo_2max until there was a decrease in body mass of 3%, which took on average $96.7 \pm 19.4\text{min}$. The subjects then consumed the drink in 30min intervals. They found that the deep mineral water was more effective in helping the subjects recover from the dehydrated state.²⁷

2.5 Performance Studies

De Pauw et al.²⁸ assessed recovery interventions on cycling performance in the heat. Nine trained males (age= $22 \pm 3\text{yrs}$) completed three different trials (active recovery, passive recovery and cold-water immersion). The subjects completed 60 minutes of steady state exercise followed by a 30 minute time trial. After the time trial, an intervention was completed and a final 12 minute time trial was completed. There was no difference in the performance but the cold-water immersion showed a more even pace for the 12 minute time trial, whereas the other two recoveries showed a

steady decline. Getting the body cold was the key to gaining a fast recovery and finishing the final time trial more efficiently.²⁸

Zhoa et al.²⁹ developed a hypothesized that VO_2max and Wingate test performance can be hindered if the subject is in a hot environment. Nine healthy endurance trained males (age= $21.6 \pm 1.2\text{yrs}$) completed a VO_2max test and Wingate anaerobic test under three different temperatures and relative humidity. The authors found that there were lower VO_2max were lower ($\sim 200\text{ml/min}$) in the hot and humid environments but there were no changes in peak power in the Wingate test. They concluded that humidity does not affect aerobic or anaerobic maximum tests but temperature can adversely affect VO_2max .²⁹

Periard et al.³⁰ determined the influence of core temperature on cardiovascular responses to moderate and intense bouts of exercise in trained and untrained individuals under heat stress. Sixteen males, eight trained cyclists (age= 29.9 ± 8.1) and eight untrained (age= $26.3 \pm 4.4\text{yrs}$), with similar body stature. The trained cyclists cycled a minimum of 250km per week. Three trials were conducted; two trials to exhaustion at 60% VO_2max and 75% VO_2max ; the final was a control at 60% of VO_2max for 60 minutes. The trials were held on a cycle ergometer and at a temperature of 40°C and 50% RH. The results showed that the trained cyclists were able to cycle further at 60% and 75% VO_2max than untrained while exposed to heat stress. In conclusion, the authors suggested increased heart rate and decreased stroke volume contributed to the rapid decline in performance after different intensities. They also showed that core

temperature was similar for both groups at exhaustion, but trained athletes were able to tolerate the heat much easier than the untrained. ³⁰

Maughan et al. ³¹ examined the effect of relative humidity on extended exercise. Eight healthy male subjects (age= 26 ± 4 yrs) were recruited. The chamber stayed at a constant $30.2 \pm 0.2^{\circ}\text{C}$ while during each treatment the humidity increased; $24 \pm 3\%$, $40 \pm 1\%$, $60 \pm 1\%$ and $80 \pm 1\%$. The subjects pedaled to a cadence of 60rpm or higher until exhaustion during each trial. Exercising in higher humidity decreased performance time. This was mainly due to the effect of humidity reducing sweat loss of the athletes which lead to adverse effects on heart rate, and decreased stroke volume and blood pressure. ³¹

Chudecka and Lubkowska³² used thermal imaging assessing body temperature changes as athletes exercised. Skin is made of isotherms that reflect heat changes both inside and out of the body. The thermal emission camera records changes in temperature on the skin. The purpose of the study was to assess temperature changed of the upper arms and forearms of volleyball players both before and after exercise. Twelve male professional volleyball players (age= 21.7 ± 1.23 yrs) exercised in a speed and endurance protocol that lasted for 90 minutes with thermal imaging completed before, immediately after, and 10 minutes after training. They concluded that the use of thermal imaging is a way to detect decreases in body temperature that could potentially correlate with maximum oxygen uptake in athletes. They also noted that because of the distribution of fat on the back of the arms, rather than the forearm,

allowed for increased temperature changes. Finally, they suggested the use of thermal imaging for increasing the chance of treating hyperthermia more effectively.³²

Mohr et al.³³ investigated the physiological responses and overall performance of soccer players in the heat. Seventeen elite male soccer players (Age: 26.6 ± 1.2) volunteered to compete in two games (one control 21°C , one hot 43°C) and after each game the subject had to run repeated sprint tests and determine core and muscle temperature. They found that the core temperature was about one degree higher in the hot environment. The authors also found that the intensity of the sprints were lower after the game played in the heat although the distance covered was higher in the heat. They concluded by stating that there is a correlation between the intensity and core temperature when exercising in the hot conditions.³³

Morton et al.³⁴ assessed whether heat shock proteins were affected by just heating of the muscle and core alone. Seven active males (age = 23 ± 3 yrs) went through a passive heating protocol where one lower limb was in a tank of warm water and the control limb stayed free from the water. Muscle biopsies were taken at the vastus lateralis on both legs. They found that heating alone did not generate significant differences in heat shock proteins concluding that only exercise in the heat can demonstrate a change in these proteins.³⁴

The exercise clothing industry has become quite successful and Davis and Bishop³⁵ looked to assess the impact that the clothing products of today have on exercise in the hot conditions. The authors reviewed 14 studies all dealing with how

clothing affects performance in hot environments. The main argument between the studies was the effect of thermal balance of synthetic and natural products. They found after reviewing many studies there was no advantage to wearing sport textiles over natural fabrics on exercise performance. They elaborated that the sport textiles should not be discouraged from being worn because being comfortable in what one exercises in is a key contributor to performance.³⁵

2.6 CorTemp Studies

In terms of measuring core temperature during exercise, Casa et al.³⁶ tested the validity of the CorTemp ingestible capsule compared to that of manually measuring rectal temperature, which has been the gold standard of core temperature measurement. Fifteen males and 10 females (age= 26.5 ± 5.3 yrs) were tested on two separate occasions. They found that the CorTemp had a significant correlation (0.86) to rectal probe temperatures with a ± 0.1 °C difference. This provides an alternative to gaining a quick and accurate measurement of core temperature. It was also found that the CorTemp did not differ if the subjects had eaten or not before the intervention. It was concluded that the CorTemp, is as accurate as the gold standard rectal probe.³⁶

As previously discussed by Casa et al.³⁶, the CorTemp device was suggested to be a viable alternative for measuring core temperature. Ganio et al.³⁷ tested the validity and reliability of various devices during exercise in the heat. Fifteen males and 10 females (age= 26.5 ± 5.3 yrs) had to walked on a motorized treadmill while multiple measurements were gained from various devices (i.e. rectal thermometer, CorTemp

ingestible pill, forehead, temporal, oral, aural, and axillary temperatures). They found that the only device capable of taking a valid and reliable temperature compared to the rectal thermometer was the CorTemp ingestible pill. This gave further validity to the product which is a minimally invasive way of gaining a proper core temperature measurement.³² In congruence with Casa et al.³⁶, Ganio et al.³⁷, and Xu et al.³⁸ demonstrated the difference in location and accuracy of temperature. Nine Army volunteers went through three sessions of walking on a treadmill for 2 hours. The authors used an ingestible pill and skin sensor to determine if there was any correlation between the two. They found that temperature of the sternum accounted for about 75% or more of the variance observed by the core temperature. They recommended ingestible pills because external sensors are location specific and their accuracy depends on anatomical sensor placement.³⁸

CHAPTER III

METHODS

The purpose of this study was to determine the effectiveness of the “Dragon Heat Polar Seat” in preventing hyperthermia in athletes exercising at above average temperatures and relative humidity. Increased temperature and relative humidity can adversely affect performance by increasing cardiorespiratory stress making it more difficult to maintain core temperature.

3.1 Research Design

The study used a counterbalanced experimental design. All participants received both the experimental and the control treatment. The order was randomized with half

of the subjects completing the control treatment first and half completing the experimental treatment first.

3.2 Subjects

Ten healthy trained runners, both male and female, ages 18-30 years, were recruited (Appendix B) from Cleveland State University (CSU) and the Cleveland community. Subjects completed the AHA/ACSM pre-participation health screen questionnaire (Appendix C) to determine eligibility to participate in the study. Subjects must have been low risk to participate in the study. All eligible subjects read and signed an informed consent (Appendix D) form approved by the CSU Institutional Review Board prior to participation. The subjects must have a VO_2 max test completed, be able to sustain a pace of 80% of VO_2 max and commit to 60 minutes in the lab for two separate sessions.

3.3 Procedures

Preparatory Procedures

The subject arrived at the Human Performance Laboratory at CSU 15 minutes prior to testing to prepare for exercise. The subject's nude weight was taken prior to the exercise and immediately after testing on a medical balance scale. The difference between the two weights was used to calculate estimated sweat rate and water loss.

VO₂max Test

All subjects completed a VO₂max test prior to testing to determine their running pace. A heart rate monitor and COSMED were used to measure VO₂. Subjects were tested on a motorized treadmill at a comfortable pace for 3 minutes at 0% incline. Once the first three minutes had elapsed the subject continued at this same pace while increasing the incline 3% every three minutes or until the subject reached exhaustion or VO₂ peak.

Heart Rate

The subjects' heart rate was continuously monitored using the Versa care telemetry system (Scott Care Inc, Cleveland, OH). Heart rates were determined from a continuous electrocardiogram (Lead II) before, during and after exercise.

Core Temperature Measurement

The CorTemp (HQ Inc, Palmetto FL) (Appendix E) is an ingestible, wireless thermostat that has been validated for determining core temperature. The CorTemp uses an ingestible thermistor encased in a capsule (approximately the size of a multivitamin pill) that is swallowed one hour prior to starting exercise. The one hour allowed for the thermistor to settle in the stomach and stabilize before measuring core temperature. The core temperature was obtained at every minute throughout the testing. Data from the thermistor is transmitted to a receiver connected to a computer that allows for continuous temperature monitoring. The CorTemp thermistor is

designed for one time use, is safe and passes through the body as if it was food and then is excreted in the stool. The CoreTemp thermistor is accurate to $\pm 0.1^{\circ}\text{C}$ when validated against measurements by a rectal probe.⁸

Blood Lactate Analysis

Blood lactate level was used to determine the efficiency of anaerobic metabolism. Blood lactate was assessed by finger prick immediately before and 2 minutes after completion of the exercise trial. The skin of the subject's finger was cleaned with an alcohol swab and allowed to dry. A sterile blood lancet was used to prick the finger to obtain a small amount of blood. The drop of blood was placed in the Lactate Plus analyzer (Nova Biomedical Corporation, Waltham, MA) to measure the lactate level. A band-aid was applied to the prick site to control any additional bleeding. A different finger was used to obtain the baseline and post exercise lactate.

Oxygen Consumption

Oxygen consumption (VO_2) was measured using indirect calorimetry. Oxygen consumption (VO_2) and carbon dioxide (VCO_2) were continuously measured during exercise using the COSMED portable K⁴b² (Cosmed; Chicago, IL) (Appendix F). The COSMED is a portable spirometer that allows for the subject to exercise freely without being tethered to an analyzer. The system was calibrated prior to the use by following the calibration protocol written for the COSMED. The COSMED provides constant measures of VO_2 at baseline, during exercise, and during recovery of the experimental protocol.

Borg's Rating of Perceived Exertion (RPE)

Borg's RPE scale (6-20) (Appendix G) was used to determine the rate of perceived exertion. The scale has verbal and numeral descriptions based on the perceived overall body exertion.

Exercise Procedure

Subjects were randomly assigned to either the treatment run or the control run during their first trial to avoid an order effect. All exercise was completed in an environmental chamber set to 85°F and 60% relative humidity. Each exercise session started at least one hour after ingestion of the CorTemp thermistor and once all baseline readings had been completed. The subjects were allowed to do any voluntary stretching that they wished prior to the running portion of the experiment.

Running Protocol

The subjects completed two runs with at least one day between trials. All runs were performed on a motor driven treadmill (Quinton Instruments Co, Seattle, WA). The two trials followed the same running protocol and data collection (Appendix H). The treadmill speed was set based on 80% of the subject's VO_2max and sustained at that pace for six, five-minute segments interspersed with three minutes of rest. During the three-minute rest periods, the subject sat on the Polar bench located inside the environmental chamber.

During the treatment run, the Polar bench was connected to the cooling unit that forced cool air on the back of the subjects while they sat. The control run followed the same procedure except the cooling unit was turned off. Subjects were also instructed to wear the same clothing during both runs.

3.4 Data Treatment and Analysis

Data was analyzed (SPSS, version 18.0) using descriptive and inferential statistics (ANOVA) (protected paired sample t-tests) to assess differences due to the independent variable (Cooling Bench) on the dependent variables (heart rate, VO_2 , core temperature, lactic acid, RPE and sweat loss). The significances level was set at .05 for the ANOVA and .06 for the protected t-tests.

CHAPTER IV

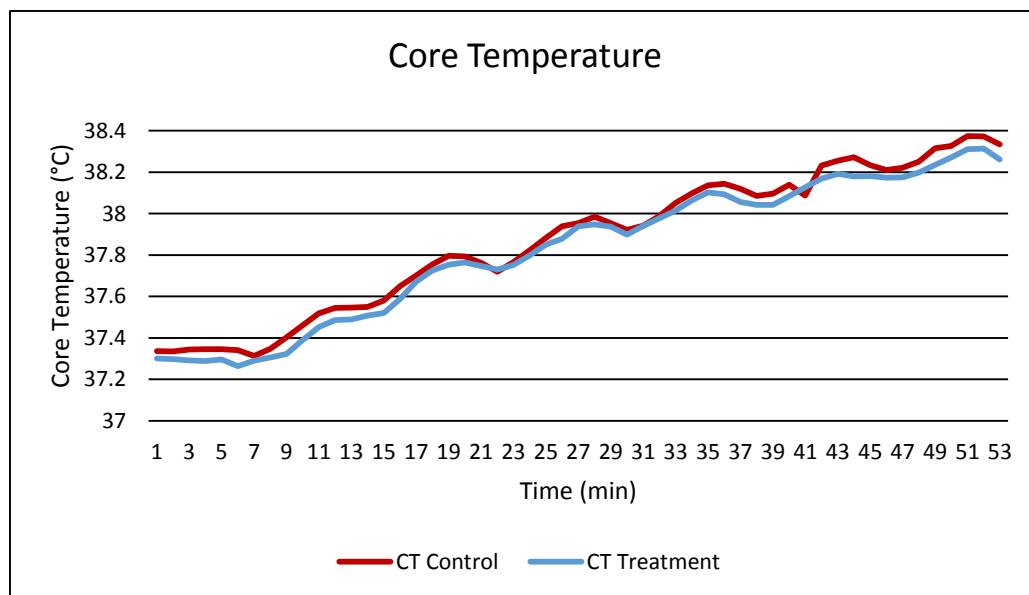
RESULTS AND DISCUSSION

The results are shown in Table 1 and Figures 1-6. Table 1 shows the subject characteristics. Figures 1-6 show the comparison between the control and treatment conditions. The subjects (Table 1) were male and female (age= 22.8 ± 2.8 ; 24.4 ± 2.6) with normal height and weight differences but similar $VO_2\text{max}$ values. The $VO_2\text{max}$ and run pace were similar due to the females being more trained than the males.

Table 1. **Subject characteristics.**

	Male	Female
Age (yrs)	24.4 ± 2.6	22.8 ± 2.8
Height (cm)	173.7 ± 4.8	159.3 ± 4.8
Weight (kg)	79.1 ± 15.0	58.5 ± 2.5
VO ₂ max (ml/min/kg)	49.9 ± 11.1	48.3 ± 4.8
Run Pace (mph)	6.8 ± 1.7	6.8 ± 0.8

As shown in Figure 1 the difference between the treatment and control average core temperature was not significant ($p=.487$). When comparing the average core temperature from the first 15 minutes to the final 15 minutes the difference was still not significant ($p=.383$). The core temperature in the study had a lower reading on average when the subjects were sitting on the “Dragon Heat Polar Seat” with the unit on compared to when the unit was turned off.

Figure 1. **Core Temperature Comparison.**

As shown in Figure 2, the VO_2 was not significantly different ($p=.370$) when using the treatment. The VO_2 showed decreased values during the treatment from the “Dragon Heat Polar Seat.” In the later stages of exercise, the treatment trial elicited lower VO_2 , suggesting increased efficiency.

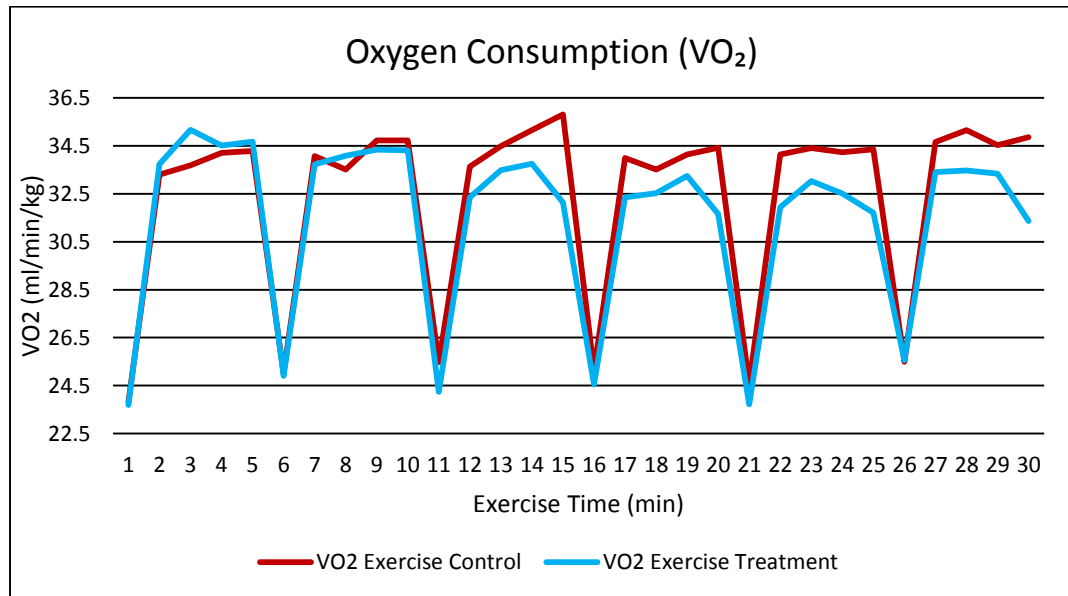


Figure 2. **Oxygen Consumption Comparison.**

In Figure 3 the difference between the heart rate of the treatment and control was not significant ($p=.243$). The heart rate on average was lower during the treatment from the “Dragon Heat Polar Seat.” When comparing the pre and post heart rates between trials the difference was still not significant ($p=.363$).

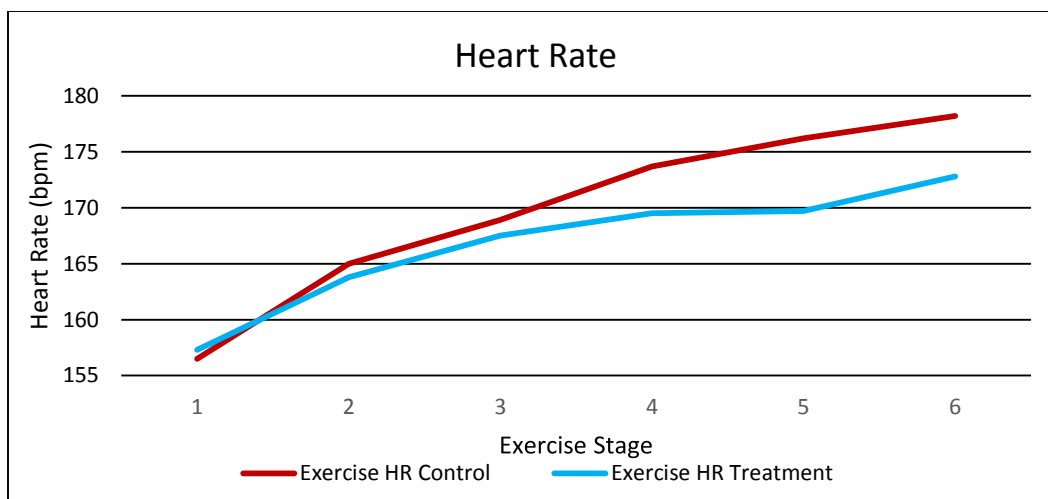


Figure 3. **Heart Rate Comparison.**

The RPE shown in Figure 4 was not significantly different ($p=.061$) in the runners using the bench. On average the subjects perceived the work being about 1 level lower with the bench compared to without. This indicated a trend that runners thought the exercise was easier during the treatment trial.

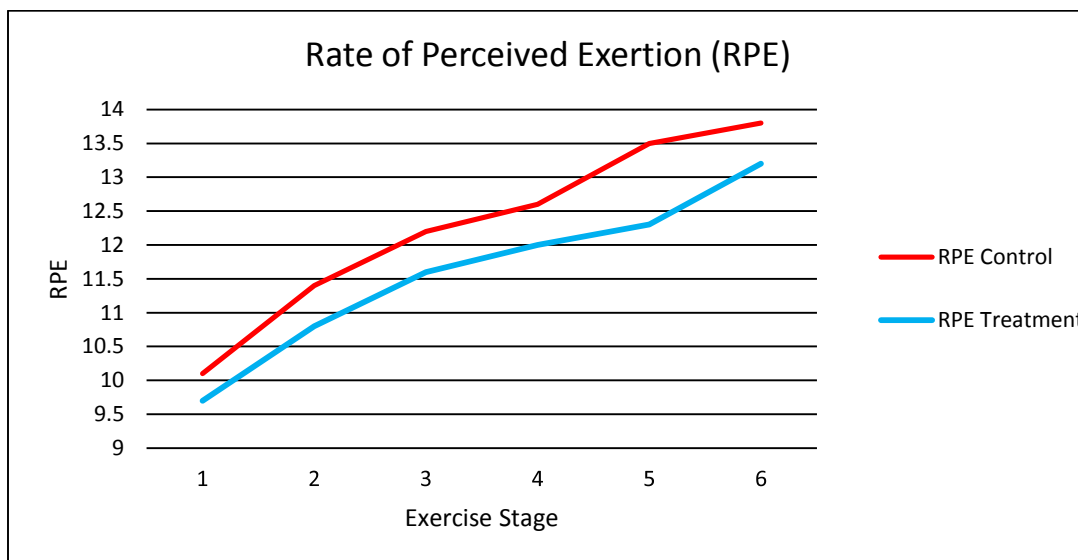


Figure 4. **RPE Comparison.**

The sweat loss seen in Figure 5 was not significantly different ($p=.146$). On average, the runners using the treatment had 124.5ml/hr less sweat lost.

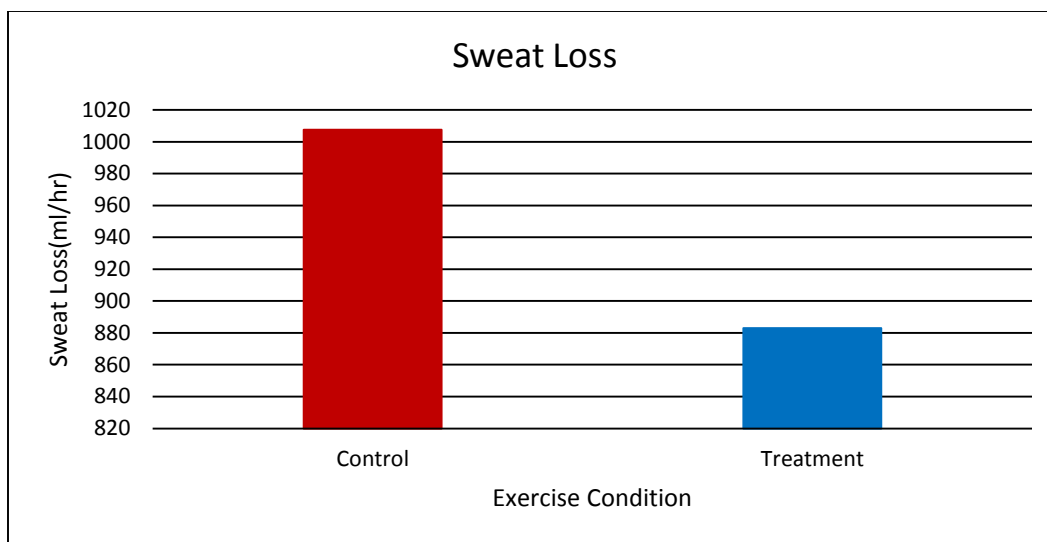


Figure 5. **Sweat Loss Comparison.**

There was a significant difference in LA production (Figure 6) in the control run ($p=.007$), but not a significant difference during the treatment run ($p=.594$). When comparing the trials there was no significant difference ($p=.421$) between the control and treatment trials. One subject's data was excluded due to above normal LA levels.

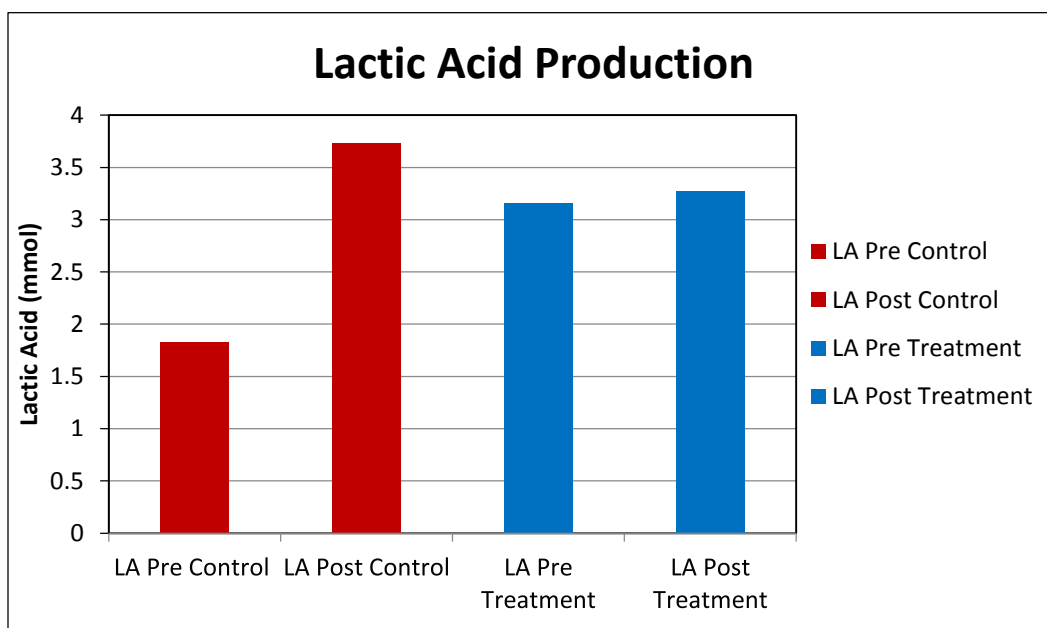


Figure 6. **Lactic Acid (LA) Production Comparison.**

4.1 Discussion

The hypothesis that there would be differences in core temperature, oxygen consumption, lactic acid accumulation, rate of perceived exertion, heart rate response and sweat rate when using the Polar seat was not supported.

There was no significant difference in core temperature on average throughout exercise before and after exercise and during the first 15 minutes compared to the last 15 minutes which refutes the findings of others^{7 11 13 16 21 25} who found a significant change in core temperature during exercise with cooling. Multiple interventions such as neck cooling, fan cooling, ice baths, etc. were used for precooling and cooling during exercise to help lower core temperature and decrease the chance of heat stroke or other heat related conditions. Although not significant the treatment group had a lower core temperature, which showed that the cooling bench had some impact. This supports Hasegawa et al.¹⁵ who demonstrated that a cooling jacket and water intake increased performance. The cooling jacket was comparable to the cooling bench in the fact that it was a cooling strategy throughout the protocol. Price et al.¹⁴ measured core temperature and performance of female soccer players both before and during a rest period. Their results supported that using a cooling strategy before and during rest were more effective at reducing thermal stress on the players and reduced core temperature. In contrast, Castle et al.¹⁷ found that cooling hindered the subjects' performance and was not a beneficial way to enhance the body's reaction to exercising in the heat. Mohr et al.³³ tested soccer players in hot and controlled environments to determine core temperature changes and performance. They found that high intensity sprints in the

heat were greatly decreased noting that the heat raised core temperature affecting performance. Brade et al.¹² indicated no advantage or disadvantage to performance or core temperature using a precooling strategy when testing athletes that were acclimated to the environment.

The Dragon Heat Polar Seat allowed for subjects to have a more comfortable running experience. The RPE was a subjective measurement of how the subjects felt while exercising and resting. Although not significant there was a trend for decreased RPE in the treatment trial (RPE=12.3) versus control (RPE=13.5). Thus, the subjects perceived that the exercise was easier during the treatment. This supports Hasewaga et al.¹⁵ who found that wearing a cooling jacket resulted in lowered RPE compared to control during endurance exercise. In the current study, the subjects also supported the lower RPE during treatment by making comments on how they felt when using the cooling. One subject noted that they felt well rested and recharged after resting on the bench for three minutes after the running segment. The RPE of the subject reinforced the comment by scoring lower on average with the cool bench on. Another subject confirmed the previous statement by stating that the control run was harder without the bench blowing cold air during the rest stages. Another subject stated that while resting on the bench during the treatment protocol, the air was so cold that they had a headache from it. Other factors could have played into this comment but they also stated that the headache went away once they started the next running stage. Another subject confirmed that the air felt too cold and air flow from behind wasn't relieving them. They would have rather seen something used for the chest, face and neck to help

cool during recovery. These statements allowed for confirmation of the significance of RPE when comparing the control and treatment protocols. Tyler and Sunderland,¹⁶ also found that perceived exertion level was lower when the neck was cooled compared to when it was not. These findings supported theirs.¹⁶

The exercise VO_2 did not show a significant difference between control and treatment. These findings support Zhao et al.²⁹ who showed that during hot and humid conditions, the VO_2 during exercise was not significantly different. During the treatment protocol the subjects had a lower VO_2 on average, which allowed them to use fewer calories for the same exercise. This was due to the resting phase that brought the VO_2 down to a lower level during the treatment protocol. Periard et al.³⁰ found that trained athletes were able to tolerate the heat at a similar percent of $\text{VO}_{2\text{max}}$ as used in the current study and showed similar increases in core temperature and heart rate.

The changes in heart rate while exercising were not significantly different when comparing the control and treatment protocol. This refutes Leicht et al.¹⁰ who recorded lower heart rates when using multiple cooling techniques compared to control. The lowered heart rate during recovery allowed for lower VO_2 , which led to higher performance during the run. Although the exercise heart rate did not show a significant difference, when the subjects completed the treatment protocol they had a lower heart rate on average. Price et al.¹⁴ showed no difference in heart rate when comparing different cooling strategies but on average, their treatment group had lower heart rates which is supported by the current study.

Sweat loss was not significantly different. Tippet et al.²⁵ measured sweat loss, hydration and core temperature in tennis players and their results refute the current findings of sweat loss in hot environments. Fluid replacement was not part of the study but showed that with dehydration, reactions to a hot environment are more detrimental to performance. In the current study, the subjects were not allowed to drink water during the exercise protocol due to wearing the COSMED mask to measure VO_2 . Hasegawa et al.²¹ found that hydration along with cooling showed increased performance. If water was available to the subjects, we may have seen greater effects when adding the cooling element of the Polar bench.

The change in lactic acid was significant in the control protocol but not in the treatment protocol. However, there was not a significant difference in lactic acid when comparing the two trials. Hargreaves³⁹ supported the findings by explaining that the control protocol showed a higher difference in lactate over 40min of exercise compared to the treatment. In the current study, we were able to treat the body with the cooling bench, which kept the lactate production lower and similar to the resting value. The subjects were instructed to wear the same or similar clothing for the treatment and control trials so they would have similar amount of cooling to the skin. Davis and Bishop³⁴ reviewed 14 studies testing different fabrics and how it related to exercise performance. Although some subjects did not wear identical clothing, they were consistent by wearing synthetics or natural fabrics in both trials. Davis and Bishop³⁴ found no significant difference in cooling rate or recovery when wearing a synthetic sport textile versus a natural cotton based shirt.

Although not significant, the Polar bench decreased core temperature and VO_2 in athletes and allowed them to perceive exercise to be less strenuous when they were able to rest with the Polar bench on. The bench showed decreased heart rate after running which could help runners recover faster and increase performance over time. In sports such as tennis and basketball, where short rest periods are important to performance, the Polar bench may be effective. The Polar bench may decrease recovery time and optimize performance in athletes.

CHAPTER V

SUMMARY AND CONCLUSION

The results did not support the hypothesis that there would be a significant difference in core temperature, oxygen consumption, lactic acid accumulation, rate of perceived exertion, heart rate and sweat loss when using the Dragon Heat Polar Seat during intermittent activity in the heat. It is therefore recommended that athletes who are exercising or competing in hot and humid environments use the Dragon Heat Polar Seat to help decrease recovery time and increase performance. Further analysis of this product is warranted to determine how it will affect other populations. The Dragon Heat Polar Seat may be used in the future in cooling systems for athletes exercising in hot and humid environments.

5.1 Limitations

The study was unable to control for multiple factors that could have affected the outcomes. Nutrition was a factor that could have affected the results. Some participants were not consistent on how much or when they ingested coffee and other exercise-enhancing products such as pre-workout supplements or energy drinks prior to the running trials that could have affected the heart rate and core temperature. The amount of temperature acclimatization was not controlled. Some subjects were acclimatized to a cold environment outside, where the last three subjects were able to exercise in a warmer environment outside prior to participating in the study, due to seasonal changes. The informed consent stated that there be no exercise prior to testing but two subjects on the cross country team had to practice prior to completing testing which may have affected their results. The hydration level prior to testing was not measured and could have limited the amount of sweat produced during the exercise. Capacity to do sustained aerobic work was measured by the VO_2max protocol prior to testing but this criteria limited the sample size ($N=10$) and population available to participate in the study.

5.2 Future Research

In the future, studies should utilize a larger sample size, control for the previously described limitations and test the Polar bench on different exercise modes such as weight training, bicycle ergometer, swimming, or the elliptical. The limitations that should be controlled for would be the nutritional intake prior to testing, acclimation to the heat, and hydration levels before and after the test. A higher temperature and

humidity in the environmental chamber may elicit different results. Also, research needs to be done on the product in an outdoor setting which allows for hydration. The product should also be researched in both younger and older populations to determine the effects of age on cooling using the Polar bench. Finally, the exercise protocol should be changed to allow for longer rest periods and longer exercise stages.

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APPENDICES

Appendix A

Dragon Heat Polar Seat

Dragon Heat Polar Seat



Appendix B

Recruitment Flyer

Research Subjects Needed

Cleveland State University

Human Performance Lab

The Human Performance Lab is looking for **MALE** and **FEMALE** volunteers ages **18-30** to participate in an experimental study based on the effects of hyperthermic stress on athletic performance. We will be using a cooling bench to determine the effects of cold air on recovery after running in a hot and humid environment.

Subjects must be able to complete a VO_2max test and 2 sessions of exercising taking 60 minutes. The sessions will be separated by at least one day. The subject must be able to run at a pace of 80% of VO_2max on a treadmill for 5 minutes for 6 intervals with rest periods of 3 minutes between them.

If you are interested in participating or have questions, please contact:

Dr. Kenneth Sparks

k.sparks@csuohio.edu

(216)687-4831

Michael Keller

m.t.keller12211@gmail.com

(330)770-2796



Appendix C

AHA/ACSM Pre-Participation Screening Questionnaire

Name _____ Date _____

AHA/ACSM Pre-participation Screening Questionnaire

Assess Your Health Needs by Marking all **true** statements

History

You have had:

- ☐ A heart attack
- ☐ Heart Surgery
- ☐ Cardiac Catheterization
- ☐ Coronary angioplasty (PTCA)
- ☐ Pacemaker/implantable cardiac
- ☐ Defibrillator/rhythm disturbance
- ☐ Heart valve disease
- ☐ Heart failure
- ☐ Heart transplantation
- ☐ Congenital heart disease

Recommendations:

If you marked any of the statements in this section, consult your healthcare provider before engaging in exercise. You may need to use a facility with a medically qualified staff.

Other health issues:

- ☐ You have musculoskeletal problems. (*Specify on back*)*
- ☐ You have concerns about the safety of exercise. (*Specify on back*)*
- ☐ You take prescription medication (s). (*specify on back*)*
- ☐ You are pregnant

Symptoms

- ☐ You experience chest discomfort with exertion.
- ☐ You experience unreasonable breathlessness.
- ☐ You experience dizziness, fainting, blackouts
- ☐ You take heart medications.

Cardiovascular risk factors

- ☐ You are a man older than 45 years.
- ☐ You are a woman older than 55 years or you have had a hysterectomy or you are postmenopausal.
- ☐ You smoke.
- ☐ Your blood pressure is greater than 140/90 mm Hg.
- ☐ You don't know your blood pressure.
- ☐ You take blood pressure medication.
- ☐ You don't know your cholesterol level.
- ☐ You have a blood cholesterol >240 mg/dl.
- ☐ You have a blood relative who had a heart attack before age 55 (*father/brother*) or 65 (*mother/sister*).
- ☐ You are diabetic or take medicine to control your blood sugar.
- ☐ You are physically inactive (*i.e., you get less than 30 minutes of physical activity on at least 3 days/week*).
- ☐ You are more than 20 pounds overweight.
- ☐ None of the above is true.

If you marked two or more of the statements in this section, you should consult your healthcare provider before engaging in exercise. You might benefit by using a facility with a professionally qualified staff to guide your exercise program.

You should be able to exercise safely without consultation of your healthcare provider in almost any facility that meets your needs.

- Proceed with test if musculoskeletal problems are minor, concerns about safety of exercise are normal, and prescription medications are not for cardiac, pulmonary, or metabolic disease.

Risk Status (Low, Moderate, High): _____

Appendix D
Informed Consent Form



INFORMED CONSENT FOR PARTICIPATION

Effectiveness of the “Dragon Heat Polar Seat” in Preventing Hyperthermic Stress in Athletes

Introduction

Thank you for considering participation in this project. Dr. Kenneth Sparks, faculty in the Department of Health and Performance, and Mr. Michael Keller, Graduate Student in the Exercise Science Program, Department of Health and Performance at Cleveland State University are inviting you to participate in a research study to be conducted in the Human Performance Laboratory at Cleveland State University.

The purpose of this study is to determine the effectiveness of the “Dragon Heat Polar Seat” in preventing hyperthermia in athletes competing in team sports in above average temperature and humidity climates.

Previous research has shown that the heat and humidity when playing sports outside has a detrimental effect on the way the body functions. “Hyperthermia is a state in which your core body temperature increases to an excess of 100 degrees F and puts the body at risk for heat related illnesses such as heat rash, cramps, or heat stroke.

The “Dragon Heat Polar Seat” looks to reverse these effects in athletes when trying to compete in the heat. The seat projects cool air out onto the back of the athlete while seating on the bench. This machine is looking to decrease the core temperature, recover the heart rate quicker, and decrease the volume of oxygen that is being used by the athletes. This in turn will allow athletes to perform at higher levels for a longer duration.

You will be asked to complete three sessions, with at least one day between sessions. The first being the maximal oxygen consumption test (allow approximately 30 minutes), then two sessions of interval running (allow 60 minutes for each session). These sessions include preparation and setup. At random, you will be selected to either have the cooling bench on your break interval or to start as a control and sit on the cooling bench without the cooling system on. All of the same measurement will be collected during both the experimental and control test.

Procedures

You will be asked to perform a maximal graded exercise test to establish run intensity. This test involves running at comfortable training pace with the treadmill elevating 3% every three minutes until maximal values are obtained. We ask that you do not do any hard training 48 hours prior to this initial test.

During the exercise testing, there exists a very small risk (1:20,000 exercise tests) of certain injuries occurring; these include abnormal blood pressure, fainting, disorders of the heart rhythm and rare instances heart attack, stroke or death. Every effort will be made to minimize these risks through screening provided by the Pre-screening questionnaire. All laboratory personnel are trained in CPR and emergency procedures are in place in the unlikely case that you would experience any of these problems.

During the procedures, using the “Dragon Heat Polar Seat” you will be asked to perform an interval protocol of running on a motorized treadmill. The interval of 5 minutes at a pace of 80-85% of the maximal capacity test will be used for every subject and this will be followed by a 3-minute interval of sitting of the bench. This process will occur six times total per trial. You will have to come into lab to obtain a thermistor capsule to ingest 1 hour prior to testing to obtain a proper core body temperature. The thermistor is FDA approved and only used as a single use instrument with no side effects. The thermistor is passed through the digestive system undissolved and eliminated from the body in fecal matter. We ask that you do not have any intense training 48 hours prior to the testing to insure you will not fatigue prior to completion of the test. Blood lactate samples will be taken both before the test as a baseline and immediately after the test to

compare. A constant heart rate monitoring system will be in place throughout the testing, along with a COSMED machine to measure volume of oxygen used.

Risks and Discomforts

Risks associated with this study include muscle soreness from the run completed. There may be joint discomfort at the knee and hip due to the hard surface of the motorized treadmill. There may be some discomfort in the finger in which the lactate blood sample is taken from. The risk of running on the treadmill is falling off of the back due to fatigue or tripping. There is a risk of heat exhaustion from running inside the chamber that will be set at a high temperature and relative humidity. There is a risk of experiencing heat related illnesses such as heat rash, cramps, or heat exhaustion (feeling of severe fatigue, profuse sweating, and disorientation) from running inside the chamber. The chamber will be set at a temperature of 85 degrees F and relative humidity of 70 percent. There is a risk of dehydration if not properly hydrated prior to exercise. "In this study possible risks would include exercising in a warm and humid environment of the environmental chamber which would be the similar to exercising in a similar environment experienced with training on a warm day."

During the exercise protocol you may become dehydrated from sweating, which could present some physical discomforts. We will monitor your safety by continuously monitoring your heart rate, body temperature and heat related symptoms. You may stop the protocol at any time if you feel too uncomfortable or we will stop you if we symptoms such as confusion, stopping of sweat production or if your core temperature rises above 103 degrees F. If this occurs, we will remove you from the environmental chamber and place you in a cooler environment until your body temperature returns to normal.

There is a risk of dehydration if not properly hydrated prior to exercise. During the exercise protocol, you will be exposed to dehydration and physical discomforts each time. In this study, possible risks would include exercising in a warm and humid environment of the environmental. We will monitor your safety by closely monitoring heart rate and possible heat related symptoms and will stop the protocol if any of these symptoms are noticed such as confusion, stopping of sweat production or if your core temperature rises above 103 degrees F

Benefits

The indirect benefits of the study are to help your understanding of how exercising in warm, humid environments may play a role in exercise performance. There are no guaranteed direct benefits, but this study may help you in knowing how to set your proper training loads to maximize your fitness level as well as educate you on the symptoms of heat illness.

Confidentiality

To protect your privacy, your name will not be used in any document of the project. A number will be assigned to the subject in place of a name. The information, however, may be used for a statistical or scientific purpose with your right of privacy retained. Dr. Kenneth Sparks and Michael Keller will be the only witnesses of the information being presented. Data will be stored in the Human Performance Lab PE60B in a locked filing cabinet.

Participation

I understand that participation in this project is voluntary and that I have the right to withdraw at any time with no consequence. I attest and verify that I have no known health problems that could prevent me from successfully participating in the interval protocol treadmill test. If I have any questions about the procedures, I can contact Dr. Kenneth Sparks at (216) 687-4831 or Mr. Michael Keller at (330) 770-2796.

I understand that if I have any questions about my rights as a participant, I can contact Cleveland State University's Review Board at (216) 687-3630.

Patient Acknowledgement

The procedure, purposes, known discomforts and risks, possible benefits to me and to others have been explained to me. I have read the consent form or it has been read to me, and I understand it. I agree to participate in this program. I have been given a copy of this consent form.

Signature: _____

Date: _____

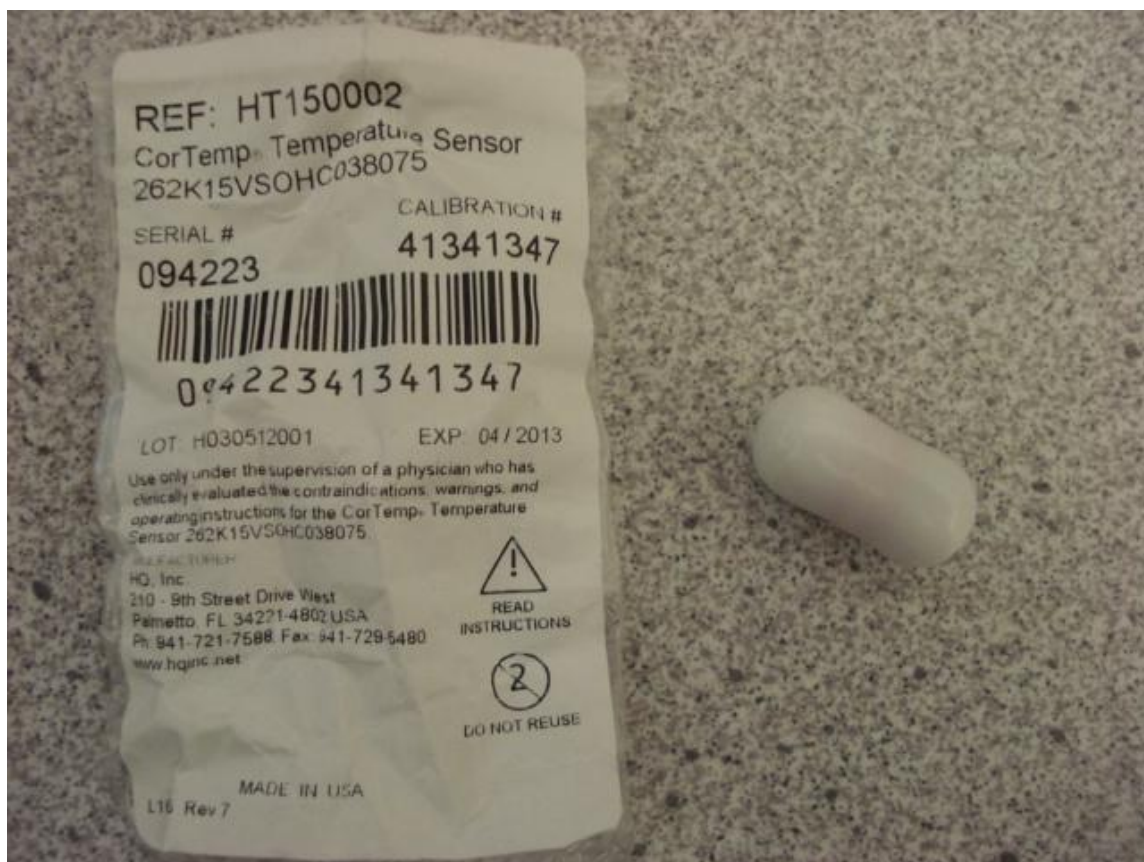
Witness: _____

Date: _____

Appendix E

CorTemp Thermistor

CorTemp Thermistor



Appendix F
COSMED K⁴b²

COSMED K4



Appendix G

Borg's RPE Scale

Rating of Perceived Exertion

Borg RPE Scale

6		How you feel when lying in bed or sitting in a chair relaxed. Little or no effort.
7	Very, very light	
8		
9	Very light	
10		
11	Fairly light	Target range: How you should feel with exercise or activity.
12		
13	Somewhat hard	
14		
15	Hard	
16		How you felt with the hardest work you have ever done. Don't work this hard!
17	Very hard	
18		
19	Very, very hard	
20	Maximum exertion	

Appendix H

Exercise Data Sheet

Time (MIN)	Exercise Protocol	V O 2	R P E	Heart Rate	Core Temp	Chamber Temp DB	Chamber Temp WB	Lactic Acid	VO2 max	Relative Humidity
1	Rest	*		*	*	*	*	*	*	*
2	Rest	*			*					
3	Rest	*			*					
4	Rest	*			*					
5	Rest	*		*	*	*	*			
6	6.8mph	*			*					
7	6.8mph	*			*					
8	6.8mph	*	*	*	*	*	*			
9	6.8mph	*			*					
10	6.8mph	*			*					
11	Rest	*			*					
12	Rest	*		*	*	*	*			
13	Rest	*			*					
14	6.8mph	*			*					
15	6.8mph	*			*					
16	6.8mph	*	*	*	*	*	*			
17	6.8mph	*			*					
18	6.8mph	*			*					
19	Rest	*			*					
20	Rest	*		*	*	*	*			
21	Rest	*			*					
22	6.8mph	*			*					
23	6.8mph	*			*					
24	6.8mph	*	*	*	*	*	*			
25	6.8mph	*			*					
26	6.8mph	*			*					
27	Rest	*			*					
28	Rest	*		*	*	*	*			
29	Rest	*			*					
30	6.8mph	*			*					
31	6.8mph	*			*					
32	6.8mph	*	*	*	*	*	*			
33	6.8mph	*			*					
34	6.8mph	*			*					
35	Rest	*			*					

36	Rest	*		*	*	*	*			
37	Rest	*			*					
38	6.8mph	*			*					
39	6.8mph	*			*					
40	6.8mph	*	*	*	*	*	*			
41	6.8mph	*			*					
42	6.8mph	*			*					
43	Rest	*			*					
44	Rest	*		*	*	*	*			
45	Rest	*			*					
46	6.8mph	*			*					
47	6.8mph	*			*					
48	6.8mph	*	*	*	*	*	*			
49	6.8mph	*			*					
50	6.8mph	*			*					
51	Rest	*			*					
52	Rest	*			*					
53	Rest	*		*	*	*	*	*		*

Exercise Data Sheet

Subject:

Bench: ON/OFF

Date:

Age:

Weight 1:

Weight 2:

Weight Change:

*Indicated when data was collected during testing