THE IMPACT OF PALM COOLING GLOVES ON CARDIOVASCULAR, THERMOREGULATORY, METABOLIC, PERCEPTUAL, AND ERGOGENIC RESPONSES PRODUCED FROM ROWING ERGOMETRY

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ABSTRACT

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Subjects (n = 34) did three rowing workouts of up to eight 2- minute stages separated by 45-60 second rests. Cardiovascular, ergogenic, thermoregulatory, perceptual and metabolic responses to workouts may be aided by intermittent palm cooling. Subjects received one of the following treatments per workout in a randomized sequence: no palm cooling, intermittent palm cooling during workouts, or palm cooling applied intermittently during workouts and post-exercise recovery. Methods: Palm cooling entailed intermittent cold (8-11^{o} C) against the palmar surface of subject's hands. Workouts began with 10 minutes of rest, followed by a 10-minute low- intensity warm-up and the workout, concluding with a 20-minute post-exercise recovery period. Work volume was examined with a two-way ANOVA with repeated measures for workout. All other variables were each examined with three-way (gender, workout, time) ANOVAs. Results: Palm cooling elicited significant effects on decreasing HR and BP. A trend for work volume differences exist as follows: NoPC < PCex, PCex&post. [BLa-] saw a significant time effect. RPE results yielded non-significant differences.

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CHAPTER ONE

INTRODUCTION

Statement of Problem

During exercise, body temperatures rise drastically, resulting in increased sweating, dehydration, and subsequent impairments in cardiovascular, thermoregulatory, and metabolic function (Caruso, 2015, p. 814). In order to continue exercising and prevent the body from hyperthermia, excess heat must be removed. Prolonged exercise results in increased evaporation and blood flow to counteract the buildup of heat. With a drastic rise in core temperature there is an added strain placed upon the cardiovascular and thermoregulatory systems, thus there is a heightened need for efficient body heat removal with increased exercise intensities and durations (Sawka, 2011, p. 157).

Purpose of the Study

Areas with glabrous (hairless) skin, such as that on the palm of the hand, play a large role in thermoregulation, or the body's ability to regulate its temperature. Glabrous skin is densely vascularized and has a large surface-to-volume ratio, allowing for rapid heat exchange (Romanovsky, 2014, p. 500). Placing a cold object against the glabrous skin of the palm expedites the removal of exercise-induced heat from the body through increased conductive heat loss. Conceptually, the removal of heat from the body's blood via cooling of the palm should allow that cooled blood from the hand to acquire additional heat once it returns to the working muscles and permit the continuation of exercise. (Grahn, 2012, p. 2559).

The purpose of this study is to assess the ability of palm cooling gloves to limit cardiovascular, temperature, and metabolic changes produced by exercise performed on a rowing ergometer. To date, several studies examined at the effects of cooling on exercise outcomes and the results have been promising, but more research is needed (Stevens, 2016, p. 829-841). To briefly elaborate on the range of results, Heller et al. (2006) concluded that cooling can be more effective than the use of anabolic steroids when looking at exercise volume, while Maunder et al. (2017) found the results to be non-significant when comparing exercise performance and core body temperature.

Need for the Study

Although there are numerous studies that examined rowing ergometry or cooling methods, there is a lack of research that compared the effects of cooling on the exercise induced effects of rowing ergometry performance. Current research also lacks information on the effects of custom-made palm cooling gloves with a pouch to insert a frozen gel pack. There are several forms of cooling studies that have been researched, such as ingestion of an ice slushy, directly cooling the neck and face, or even pouring cold water directly on top of the subject (Stevens, 2016). Examination of a specific, uncommon style of cooling, especially if the results are promising, has the potential to inspire future research projects along the same lines.

Significance of the Study

Findings from this study may provide evidence needed to support the impact of wearing palm cooling gloves during rowing trials. Having data that shows palm cooling improves cardiovascular, metabolic, and thermoregulatory effects will provide validity to usage of cooling during rowing ergometry. Positive results may promote the use of palm cooling gloves or other cooling methods during competitive rowing training. Demonstrating the efficacy of palm cooling gloves during exercise may also translate to different forms of activity such as outdoor work (e.g. gardening) or military use (e.g. soldiers in hot climates). Further research is needed to confirm the overall effectiveness of cooling during exercise. A new form of cooling that can effectively limit exercise produced changes in the body will provide motivation for continued research on this topic.

Research Questions

1. Does intermittent palm cooling impact the cardiovascular responses seen during high intensity rowing ergometry?
2. Does intermittent palm cooling impact the thermoregulatory responses seen during high intensity rowing ergometry?
3. Does intermittent palm cooling impact the metabolic response seen during high intensity rowing ergometry?
4. Does intermittent palm cooling impact rate of perceived exertion (RPE) during high intensity exercise?
5. Does intermittent palm cooling impact the total exercise volume during high intensity rowing ergometry?

Definition of Terms

Glabrous skin is characterized by the absence of hair, dense vascularization, the presence of a large surface-to-volume ratio. To meet this requirement, this type of skin is located distally (Romanovsky, 2014, p. 500)

Pre-cooling is defined as the application of cooling prior to a test of endurance performance or capacity, whereas mid-cooling is cooling concurrent to an exercise test. (Stevens, 2016).

Mid-cooling has also been referred to as per-cooling, but this term appears less frequently, due to the possibility of confusion between pre-cooling and per-cooling (Bongers, 2015).

Palm cooling is when a cold object, usually in the form of an ice or gel pack, is applied to a human subject's palm with the intention to increase the rate of body heat removal via conduction.

CHAPTER TWO

LITERATURE REVIEW

Need for Palm Cooling

Body heat increases with exercise, which can impact the body and its function. With elevated core body temperatures, the result of producing more body heat than the body is able to remove, have a negative impact on overall exercise performance. Being able to efficiently clear body heat may delay fatigue and improve exercise performance (Bongers, 2014). In drastic cases, when the misbalance between heat production and heat loss during exercise is extreme, severe heat illnesses, such as heat stroke can develop. Rowell et al. (1974) cites several major problems to human cardiovascular adjustments to exercise and heat stress, including how blood flow is distributed during various forms of exercise, how the adjustments are altered when work is prolonged, and how blood flow and blood volume distribution are adjusted during heat stress.

Palm Cooling and Rowing

As previously mentioned, the more strenuous the bout of exercise is, the more body heat is likely to be produced and accumulate. A mode of exercise that is particularly difficult, especially to those who are unfamiliar with the movement, is rowing on an ergometer. This movement is a full body exercise, which mainly relies on aerobic metabolism (Slater, 2005, p 1387-1388). Having subjects who are not trained at rowing, such as the subjects in the study by Roberts et al. (2005), requires multiple familiarization sessions that focuses on form correction and improved exercise efficiency. Familiarization sessions, in theory, prevent the data from being skewed as a result of subject overexertion due to improper form.

Types of Palm Cooling

Since heat accumulation can have a negative effect on exercise, many researchers sought ways to efficiently remove excess body heat in order to improve exercise performance and mitigate the risk of heat-related injury. A systematic review by Stevens et al. (2016) observed the effects of pre-cooling and mid-cooling in 20 separate studies. Several methods of cooling were used, such as cooling hairless skin with cold packs and a cold-water spray, all with a common goal; to increase endurance performance. The collective data showed the use of cooling during an exercise test can help reduce the negative consequences of exercise induced heat stress on endurance exercise capacity and performance (Stevens, 2016, p. 839).

In the current study, the chosen method of cooling was mid-cooling via application of frozen gel packs to the palms of the subjects. In a similar study, Hsu et al. (2005) used a water-cooled, vacuum-sealed palm-cooling device to induce mid-cooling during cycle ergometer trials. While efficient, this particular cooling device is not versatile enough to be used on a rowing ergometer. This study had positive results, with data that shows heat removal through the palm of the hand has the possibility to decrease tympanic temperature, increase oxygen uptake and lactate removal during submaximal exercise. Reducing these negative outcomes contributed to a decrease in the time required to complete an absolute volume of work. (Hsu, 2005, p. 96-97).

Purpose of the Study

With a protocol comprised of absolute workloads and durations, the ideal outcome is clearly not to decrease time required to complete the work, but rather to observe palm cooling's impact on the cardiovascular, metabolic, and thermoregulatory effects during multiple two-minute stages on a rowing ergometer. Several studies, including those previously mentioned, showed cooling techniques have great potential to positively affect exercise outcomes. However, research is extremely limited when it comes to the application of cooling techniques during rowing ergometer workouts, as well as looking at this specific form of palm cooling.

Palm cooling can also be beneficial for situations other than resistance or endurance exercise. Kuennen et al. analyzed the possible benefits palm cooling has on reducing heat strain in military subjects during a simulated armored military vehicle transport (2009). This study stated, during desert operations, the interior of armored vehicles reaches temperatures as high of 54.5^{o}C (130.1^{o}F). Subjects entered a temperature-controlled chamber to simulate the interior of an armored vehicle and were randomly assigned to one of three groups; no palm cooling (NC), palm cooling (PC), or palm cooling with negative pressure (PCVAC). The results showed those with palm cooling maintained a statistically significantly lower body core temperature while in a heated temperature chamber. Palm cooling reduced overall thermal strain in their hyperthermic subjects. There was no significant difference between the PC and PCVAC groups. Palm cooling should be strongly considered in conditions where elevated body temperatures are likely. However, palm cooling is impractical in many situations, so more research needs to be done to make palm cooling more practical and accessible.

CHAPTER THREE

METHODS

Study Design

Each subject will make six laboratory visits, beginning with three familiarization sessions, followed by three workouts, with sessions being at least three days apart from each other. The two main goals of familiarization sessions are to allow subjects to become comfortable with the palm cooling gloves and developing proper rowing technique. Member(s) of the University of Louisville Rowing Team will provide proper instruction and form correction at familiarization sessions. As part of the first familiarization session, anthropometric measurements, including height, weight, leg length, arm length, and torso length will be collected. In addition, body composition data will be collected via Bioelectrical Impedance (BIA). Familiarization sessions should last about 25 minutes each. If the subject does not comply with the study requirements or if they are not able to complete the protocol, they will be withdrawn from the project.

To begin workouts, subjects will sit quietly for 8-10 minutes. During that time, an assistant will put a heart rate monitor and watch onto the subject. Participants will also have an automated blood pressure cuff wrapped around the right arm and temperature sensors placed on the right thigh and forearm, as well as on the palm of the left hand. After 8-10 minutes, the following pre-exercise measurements will be obtained: heart rate, blood pressure, blood lactate concentration, skin temperatures of the right thigh and forearm and left hand, as well as ear canal temperature. Once the subject's fingertip has been cleaned with an alcohol prep pad, a sterile lancet will puncture skin and ~2μl of blood will be extracted that will be immediately placed upon a test strip to measure lactate. Ear canal temperature, measured with a hand-held device will estimate the temperature of blood within the subject's head.

After the pre-exercise measurements conclude, subjects will perform a ten-minute low-intensity (75-90 watt) warm-up on a stationary bicycle. Each subject will continue to wear the heart rate monitor, watch, temperature sensors and blood pressure cuff as they ride the bike. The same pre-exercise measurements, aside from blood lactate concentration, will also be obtained after the warm-up. Subjects will then perform the rowing ergometer protocol. The protocol, if the participant is a male, is eight two-minute stages executed at the following power outputs: 100 watts, 150 watts, 200 watts, and concludes with five consecutive 250 watt stages. If the participant is a female, the protocol is as follows: 100 watts, 130 watts, 160 watts, and concludes with five consecutive 190 watt stages. Drag settings on the ergometer will remain at five and ten for female and male subjects respectively. Regardless of their gender, subjects will have 45-second rests after the first four stages; thereafter they will receive 60-second rests after each stage. Subjects will continue to wear the heart rate monitor, watch and temperature sensors as they row. For clarification, the data collection sheet used at workouts can be seen in Appendix D.

During the first four rest periods heart rates and temperatures of the four (right forearm and thigh, left hand, ear canal) sites examined in this study, will be collected. During the second 60-second rest period, subjects will submit to a blood lactate concentration measurement and provide a rate of perceived exertion (RPE) value based on how challenging the workout is up to that point. RPE values will be expressed on a 6 (very easy) to 20 (extremely hard) scale. During each of the final three 60-second rest periods heart rates and temperatures of the four sites will be collected. After the eighth and final rowing stage (assuming subjects can do all eight stages), post-exercise measurements immediately commence. At 0-, 5-, 10-, 15- and 20-minutes post-exercise heart rate, blood pressure, blood lactate concentration and temperature measurements at the four sites will be obtained. Also, at 20-minutes post-exercise, subjects will give another RPE value to rate the rigor of the entire workout.

Research Questions

1. Does intermittent palm cooling impact the cardiovascular responses seen during high intensity rowing ergometry?
2. Does intermittent palm cooling impact the thermoregulatory responses seen during high intensity rowing ergometry?
3. Does intermittent palm cooling impact the metabolic response seen during high intensity rowing ergometry?
4. Does intermittent palm cooling impact rate of perceived exertion (RPE) during high intensity exercise?

5. Does intermittent palm cooling impact the total exercise volume during high intensity rowing ergometry?

Intervention

During each of the three familiarization sessions, subjects will put on gloves prior to the warm-up that are identical to the ones they will wear during the final three visits. The sequence of their final three workout treatments will be determined by a coin toss. If a treatment involving the pre-cooled gel packs is selected, they will be at a temperature of 8.1° C (46.6° F) when inserted into the gloves and will gradually warm from body heat during the 5-6 minutes they remain in the gloves.

Subjects will be randomly assigned to one of three workouts during each of the three final visits. Each subject will participate in all three workouts that may be briefly described as follows: no palm cooling (NoPC), palm cooling during exercise (PCex), and palm cooling during exercise and recovery (PCex&post). With the no palm cooling selection, subjects will still wear the gloves, but no cooling gel packs will be inserted. During palm cooling with exercise, cooling gel packs (8.1° C) will be inserted into the gloves at the end of the first stage, and reinserted after the fifth rowing stage. For that same workout, the gel packs will be removed at the conclusion of the third and seventh rowing stages. For the workout whereby palm cooling is administered during exercise and recovery, the gel pack protocol is identical to the palm cooling during exercise workout, except for the former workout gel packs are inserted at 0-minutes post-exercise, and reinserted at 10-

minutes post-exercise. For that same workout gel pack removal occurs at 5- and 15-minutes post-exercise.

Instrumentation

Data collection will be manually recorded during workouts. An assistant using a stopwatch will time exercise and rest periods. Workloads (in watts) and the volume of work covered as a function of distance (in meters) will be collected from Concept2 Model D Rowing Ergometer system. Heart rate will be collected continuously during exercise with a Polar H10 Heart Rate Sensor. Blood pressure will be collected automatically via an Omron BP742 Blood Pressure Monitor. Temperatures of the left hand, right thigh, and right forearm will be collected from Stress Thermometer Thermistors. Auditory temperature will be collected by Braun ThermoScan 5 Ear Thermometer. Blood lactate levels will be measured from ~2μl of fingertip blood that is immediately placed on a test strip inserted within a calibrated analyzer (Accutrend; Hawthorne, NY). The Borg Rating of Perceived Exertion (RPE) Scale will be used to gauge RPE at various times throughout the workout.

Participants and Setting

There were 34 college-aged subjects who participated in this research study, 10 females and 24 males, all of which attend the University of Louisville. During the initial laboratory visit in the Wendy Novak Diabetes Lab, subject's height, weight, and body composition were measured via a stadiometer and Bioelectrical Impedance respectively. Leg, arm and torso lengths were recorded from the left side of subject's bodies with a cloth measurement tape in triplicate. Each participant was required to complete the informed consent prior to beginning the study. All subjects were fluent in the English language and were able to understand prompts during the project. Participation was completely voluntary and subjects did not receive compensation while they were in the study.

Protection of Human Subjects

Subjects gave informed written consent and were in good health to participate in this study. Subjects were free of the following; diabetes, exercise-induced asthma, high blood pressure, an abnormally high resting heart rate, heart disease, an overactive thyroid gland, ailments to muscles and bones, and convulsive disorders. If subject was a female of childbearing age and wished to participate, she had to also provide proof that they used birth control. Upon giving informed consent and filing out a medical questionnaire that showed the participant was healthy to participate, the subject was admitted into the study by the principal investigator, Dr. John F. Caruso.

Data Analysis

Prior to analysis, data was examined with Z-scores to identify outliers and for compliance to ANOVA assumptions (normality, independence, and equal variances). Data were considered statically significant at p values ≤ 0.05. Work volume data was analyzed using a Two-Factor ANOVA with repeated measures for workout. All other dependent variables were examined using 3-way (gender, workout, time) ANOVAs with repeated measures for time and workout. A Simple Effects Post-Hoc was then used to place the dependent variables into groups that were statistically similar to one another. This allows for comparisons of all levels of the Independent Variables and gives flexibility when analyzing data.

Using a within-subjects design, there were three different workouts each subject engaged in, one with no palm cooling, another with palm cooling during exercise, and finally one with palm cooling during exercise and recovery. Another independent variable was the time of data collection. Each workout was comprised of up to 14 time periods in which data were collected. They include pre-exercise (baseline), followed by post bicycle warm-up values. Once the rowing ergometry began, data was collected after each two-minute rowing stage (post stage 1, post stage 2, post stage 3, post stage 4, post stage 5, post stage 6, post stage 7, post stage 8-assuming they completed all eight stages), as well as at five-minute intervals post-exercise (post 5-min, post 10-min, post 15-min, post 20-min). Subjects were encouraged to perform as much of the rowing protocol as they could. For those that completed all eight stages, 0-minutes post-exercise measurements coincided with those collected at the conclusion of stage eight. For those unable to complete all eight stages, 0-minutes post-exercise measurements coincided with the conclusion of their rowing efforts. The third independent variable was gender, which was separated into male and female groups.

In this study, there were five categories of dependent variables. Thermoregulatory variables were auditory temperature, left hand temperature, right forearm temperature, and right thigh temperature. Cardiovascular variables were systolic blood pressure, diastolic blood pressure, mean arterial pressure, heart rate and rate pressure product. The metabolic dependent variable measured was blood lactate concentration [BLa^-]. The dependent variable for exercise intensity perception was rate of perceived exertion (RPE). Finally, the dependent variable used to measure volume of work was the total amount of meters rowed per visit.

CHAPTER FOUR

RESULTS

The intention of the fourth chapter is to examine the results of the graduate thesis research study. In this section, there will be a characterization of the subjects who participated in the study, as well as an analysis of the data gathered from the study. There will be tables and explanations showing the results that were gathered throughout this research study.

Purpose of the Study

The purpose of this study is to assess the ability of palm cooling gloves to limit cardiovascular, temperature, and metabolic changes produced by exercise done on a rowing ergometer. To date, several studies have looked at the effects of cooling on exercise outcomes and the results have been promising, but more research is needed (Stevens, 2016, p. 829-841. To elaborate on the range of results, Heller et al (2006 made the conclusion that cooling can be more effective than the use of anabolic steroids when looking at exercise volume, while Maunder et al (2017 found the results to be non-significant when comparing exercise performance and core body temperature.

Description of Participants

There were 34 college-aged subjects who participated in this research study, 10 females and 24 males, all of which attend the University of Louisville. During the initial laboratory visit in the Wendy Novak Diabetes Lab, subject's height, weight, and body composition were measured via Bioelectrical Impedance. Each participant was required to complete the informed consent prior to beginning the study.

Statistical Design

The work volume data was analyzed using a Two-Factor ANOVA with repeated measures for workout. The two-way analysis looked at gender (male, female) and the three workouts (NoPC, PCex, PCex&post). Data was considered statistically significant with a p-value ≤ 0.05. A simple effects post-hoc identified the source of the differences.

Effects of Palm Cooling on Cardiovascular Function

Blood Pressure

Both systolic blood pressure (SBP) and diastolic blood pressure (DBP), measured in millimeters of mercury (mmHg), were measured six times during each of the three data collection sessions. Blood pressure was examined using a 3-way (gender, workout, time) ANOVA, with results showing an effect for time in both SBP and DBP.

For SBP, the time that produced the highest mean blood pressure (121 ± 1.6mmHg) was the post-bicycle warmup, which was significantly higher ($p \leq 0.05$) than the pre-exercise and the four post-exercise SBP measurements. Table 2 shows the results (mean $\pm$ SEM) for SBP in mmHg for each data collection point.

Table 1

Time Effect for Systolic Blood Pressure.

Pre-ex	Post-bike	Post 5-min	Post 10-min	Post 15-min	Post 20-min
121 ± 1.6^{b}	126 ± 1.5^{a}	121.4 ± 1.2^{b}	117 ± 1.1^{c}	114.5 ± 1.0^{c}	115 ± 1.0^{c}

a > b > c, [a]: post-bike, [b]: pre-ex, post 5-min, [c]: post 10-min, post 15-min, post 20-min

DBP results showed the pre-exercise and post-bicycle warmup values were significantly higher than the four post exercise measurements. Table 3 shows DBP (mean $\pm$ SEM) results in mmHg for each data collection point.

Table 2

Time Effect for Diastolic Blood Pressure.

Pre-ex	Post-bike	Post 5-min	Post 10-min	Post 15-min	Post 20-min
78 ± 0.94^{a}	77.5 ± 1.4^{a}	65.1 ± 0.9^{b}	62.5 ± 1.0^{b}	63.2 ± 0.9^{b}	62.6 ± 0.9^{b}

a > b, [a]: pre-ex, post-bike, [b]: post 5-min, post 10-min, post 15-min, post 20-min

Heart Rate

Heart rate (HR) was examined using a 3-way (gender, workout, time) ANOVA, with results showing effects for both time and workout. The results expectedly showed that, as the workout proceeded and increased in intensity, there was a relationship between time and HR. Measurements that followed stages 4, 6, 7, and 8 produced the highest average values, followed by, in descending order, post stage 3, post stage 2, post stage 1, 5-min post-exercise, 10-min post-exercise, post-bike, 15-min post-exercise, 20-min post-exercise, and pre-exercise. Table 4 shows HR results (mean $\pm$ SEM) in beats per minute measured at each data collection point.

Table 3

Time Effect for Heart Rate

Pre-ex	Post-bike	Post s1	Post s2	Post s3	Post s4	Post s6	Post s7	Post s8	Post 5-min	Post 10min	Post 15-min	Post 20-min
72 ± 1[a]	95 ± 2[b]	124 ± 2[c]	145 ± 2[c]	160 ± 2[c]	174 ±2[d]	177 ± 2[d]	177 ± 2[d]	177 ± 2[d]	101 ± 2[b]	97 ± 1.5[b]	94 ± 1.4[b]	92 ± 1.4[b]

a < b < c < d, [a]: post stage 4, post stage 6, post stage 7, post stage 8, [b]: post stage 3, [c]: post stage 2, post stage 1, [d]: post 5-min, post 10-min, post-bike, post 15-min, post 20-min

In addition, there was a workout effect for HR with regards to the three cooling treatments. Results showed average heart rate values were significantly higher during the NoPC workouts compared to the PCex workouts. In contrast PCex&post average heart rate values were not unlike those from the other two workouts. Table 5 shows the heart rate results (mean ± SEM) in beats per minute for the three workouts.

Table 4

Workout Effect for Heart Rate

NoPC*	PCex*	PCex&post*
126.1 ± 2.0[a]	124.6 ± 2.0[b]	125.5 ± 1.9[a,b]

a > b, NoPC[a], PCex&post[a,b], PCex[b]

Mean Arterial Pressure

Mean arterial pressure (MAP) is calculated by taking the difference between systolic and diastolic blood pressure values, dividing that value by 3, and then adding the diastolic blood pressure value to that number. MAP was statistically examined using a 3-way (gender, workout, time) ANOVA, with the results showing a time effect. The highest average MAP values came from the pre-exercise and post-bicycle measurements. The four post-exercise measurements (post 5-min, post 10-min, post 15-min, post 20-min) were significantly lower in terms of MAP. Results (mean ± SEM in mmHg) for MAP appear in the table below.

Table 5

Time Effect for Mean Arterial Pressure (MAP)

Pre-ex	Post-bike	Post 5-min	Post 10-min	Post 15-min	Post 20-min
93.2 ± 0.91 [a]	94.4 ± 1.1[a]	83.7 ± 0.84[b]	80.6 ± 0.87 [b]	80.2 ± 0.81 [b]	80.0 ± 0.8 [b]

a > b, [a]: pre-ex, post-bike, [b]: post 5-min, post 10-min, post 15-min, post 20-min

Rate Pressure Product

Rate pressure product (RPP) is calculated by multiplying systolic blood pressure (mmHg) by heart rate (beats per minute). RPP is expected to increase linearly with an increase in workload intensity. It was statistically examined using a 3-way (gender, workout, time) ANOVA, with the results showing a time effect. Average RPP values were significantly higher ($p < 0.05$) at the post-bike, post 5-min, and post 10-min data collection points when compared to the post 15-min, post 20-min, and pre-exercise measurements. RPP results (mean ± SEM) appear in Table 7 below.

Table 6

Time Effect on Rate Pressure Product (RPP)

Pre-ex	Post-bike	Post 5-min	Post 10-min	Post 15-min	Post 20-min
8954 ± 163 [b]	13217 ± 1145[a]	12408 ± 303[a]	11419 ± 239 [a]	10674 ± 229 [b]	10590 ± 209 [b]

a > b, [a]: post-bike, post 5-min, post 10-min, [b]: post 15-min, post 20-min, pre-ex

Effects of Palm Cooling on Thermoregulation

Left Hand Temperature

Left hand temperature (LHT) was measured by a wired thermistor attached to the subject's palm. It was statistically examined using a 3-way (gender, workout, time) ANOVA, and results produced a two-way (time by workout) interaction. The time by workout results state that left hand inter-workout temperature differences were only significant ($p < 0.05$) at certain data collection points. The NoPC workout had a significantly average higher LHT values than both PCex and PCex&post at the following time points: post set 2, post set 3, post set 4, post set 6, post set 7 and post set 8. In contrast, both the NoPC and PCex groups had significantly higher temperatures than the PCex&post group at the post 5-min, post 10-min, post 15-min, and post 20-min times. Results (mean ± SEM in ºC) for left hand temperatures are provided below:

Table 7

Time by Workout Effect for Left Hand Temperature

	Pre-ex	Post bike	Post s1	Post s2	Post s3	Post s4	Post s6	Post s7	Post s8	Post 5min	Post 10min	Post 15min	Post 20min
No PC	31.0 ±0.4	32.6 ±0.4	32.5 ±0.3	32.4 ±0.4 *	32.9 ±0.4 *	33.5 ±0.3 *	34.5 ±0.3 *	34.8 ±0.3 *	34.9 ±0.2 *	36.0 ±0.2 *	36.1 ±0.2	36.0 ±0.2*	35.9 ±0.2*
PCex	31.2 ±0.4	32.6 ±0.5	32.5 ±0.3	26.6 ±0.6 *	27.0 ±0.6 *	31.0 ±0.5 *	28.8 ±0.5 *	28.5 ±0.6 *	32.1 ±0.5 *	34.4 ±0.3 *	34.9 ±0.3	34.9 ±0.3*	35.2 ±0.3*
PCex & Post	30.7 ±0.5	32.3 ±0.4	32.1 ±0.3	26.3 ±0.5 *	26.3 ±0.6 *	30.4 ±0.5 *	27.7 ±0.6 *	28.3 ±0.6 *	32.1 ±0.5 *	29.2 ±0.6 *	33.9± 0.4	28.9 ±0.6*	33.5 ±0.4*

*: NoPC > PCex, PCex&post at post stage 2, post stage 3, post stage 4, post stage 6, post stage 7, post stage 8. NoPC, PCex > PCex&post at post 5-min, post 15-min, post 20-min.

Right Thigh Temperature

Right thigh temperature (RTT) was measured by a wired thermistor attached to the anterior portion of the subject's right thigh. It was statistically examined using a 3-way (gender, workout, time) ANOVA, with the results showing a time by workout effect. Results showed the NoPC workout produced significantly higher ($p < 0.05$) average right thigh temperatures than the PCex and PCex&post workouts at the post stage 6, post stage 7, post stage 8, and post 5-min measurements. Results for right thigh temperature (mean ± SEM in °C) are shown in Table 10.

Table 8

Time by Workout Effect for Right Thigh Temperature

	Pre-ex	Post-bike	Post s1	Post s2	Post s3	Post s4	Post s6	Post s7	Post s8	Post 5min	Post 10-min	Post 15-min	Post 20-min
No PC	31.8 ±0.3	32.0 ±0.3	32 ± 0.2	32.2 ±0.3	32.2 ± 0.3	32.8 ±0.3	35.3 ±1.1 *	35.5 ±1.2 *	36.1 ±1.4 *	36.2 ±1.1 *	35.0 ±0.6	34.8 ±0.5	34.6 ±0.5
PCex	31.7 ±0.2	31.8 ±0.3	31 ± 0.3	32.1 ± 0.3	32.2 ± 0.3	32.5 ±0.3	33.1 ±0.4 *	33.2 ±0.4 *	33.6 ±0.4 *	34.4 ±0.5 *	34.3 ±0.4	34.1 ±0.4	33.8 ±0.3
PCex & post	31.7 ±0.3	31.8 ±0.3	31 ±0.3	32.0 ±0.3	32.2 ±0.3	32.3 ±0.4	32.8 ±0.4 *	32.8 ±0.4 *	32.6 ±0.3 *	34.4 ±0.5 *	34.3± 0.4	33.9 ±0.4	33.8 ±0.4

*: NoPC > PCex, PCex&post at post stage 6, post stage 7, post stage 8, & post 5-min

Right Forearm Temperature

Right forearm temperature (RFT) was measured by a wired thermistor attached to the anterior portion of the subject's right forearm. It was statistically examined using a 3-way (gender, workout, time) ANOVA, with the results showing a significant time effect. Results showed RFT was significantly higher ($p < 0.05$) during post stage 6, post stage 7, post stage 8, post 5-min, post 10-min, post 15-min, and post 20-min when compared to the first six measurements. Results for right forearm temperature (mean ± SEM in °C) are shown in Table 11.

Table 9

Time Effect for Right Forearm Temperature

Pre-ex	Post-bike	Post s1	Post s2	Post s3	Post s4	Post s6	Post s7	Post s8	Post 5min	Post 10min	Post 15min	Post 20min
32.3 ±0.2 a	33.3 ±0.2 a	33.2 ±0.2 a	33.4 ±0.2 a	33.9 ±0.3 a	34.6 ±0.4 a	35.6 ±0.4 b	36.0 ±0.5 b	35.8 ±0.4 b	36.6 ±0.4 b	36.4 ±0.4 b	36.1 ±0.4 b	35.8 ±0.4 b

a < b, [a]: Pre-ex, post stage 1, post-bike, post stage 2, post stage 3, post stage 4, [b]: post stage 6, post 20-min, post stage 8, post stage 7, post 15-min, post 10-min, post 5-min.

Auditory Temperature

Auditory temperature was measured in the subject's left ear with a Braun ThermoScan 5 Ear Thermometer. Auditory temperature was examined statistically by using a 3-way (gender, workout, time) ANOVA. There was no statistically significant difference ($p < 0.05$) in auditory temperature when comparing the NoPC, PCex, and PCex&post workout groups.

Effects of Palm Cooling on Metabolic Function

Blood Lactate

Blood lactate concentration ([BLa$^-$]) is measured by drawing a small sample of blood onto a test strip inserted within a calibrated [BLa$^-$] analyzer. For this study, there were effects for both time and workout when results were examined using a 3-way (gender, workout, time) ANOVA. For the time effect, [BLa$^-$] levels (mmol/L) were statistically the lowest on average for the pre-exercise measurement (1.8 ± 0.1 mmol/L). Average [BLa$^-$] levels increased significantly to the mid-exercise measurement (9.1 ± 0.6 mmol/L) and 5 minutes post-exercise (9.9 ± 0.5 mmol/L). Blood lactate levels then decreased progressively throughout the 10-minute, 15-

minute, and 20-minute post-workout measurements. [BLa$^-$] results (mean ± SEM in mmol/L) appear in the table below.

Table 10

Time Effect for Blood Lactate Concentration [BLa$^-$].

Pre-ex	Mid-ex	Post 5-min	Post 10-min	Post 15-min	Post 20-min
1.8 ± 0.1 [a]	9.1 ± 0.6[c,d]	9.9 ± 0.5[d]	8.5 ± 0.4 [c,d]	7.2 ± 0.4[b,c]	6.2 ± 0.3[b]

a < b < c < d, [a]: pre-ex, [b]: post 20-min, [b,c]: post 15-min, [c,d]: post 10-min, mid-ex,
[d]: post 5-min

As previously mentioned, there was also a significant workout effect associated with [BLa$^-$] values. The data showed there were significantly higher average lactate levels for the NoPC workout (8.1 ± 0.4 mmol/L) as compared to the PCex (6.9 ± 0.3 mmol/L) and PCex&post (6.4 ± 0.3 mmol/L) workouts.

Effects of Palm Cooling on Rate of Perceived Exertion

Rate of Perceived Exertion (RPE) was measured using the Borg Scale of Perceived Exertion (Borg, 1970). Subjects rated their own perceived exertion from 6-20 on the Borg Scale, with 6 being considered "no exertion" and 20 being considered "maximal effort." Rate of Perceived Exertion was examined statistically by using a 3-way (gender, workout, time) ANOVA. There was no statistically significant difference ($p < 0.05$) for RPE when comparing the NoPC, PCex, and PCex&post workout groups. Results for RPE (mean ± SEM in mmol/L) are shown in Table 12 below.

Table 11

No Effect for Rate of Perceived Exertion (RPE).

TIME	NoPC	PCex	PCex&post
Mid-Ex	15.4 ± 0.3	15.1 ± 0.3	15.2 ± 0.3
Post-Ex	15.5 ± 0.4	15.4 ± 0.6	16.0 ± 0.4

Effects of Palm Cooling on Exercise Volume

Total amount of work, measured in meters (m) for each workout showed palm cooling had an effect for both the PCex and PCex&post workouts, meaning that subjects rowed significantly farther ($p \leq 0.05$) with both palm cooling workouts as compared to the NoPC treatment. Results (mean ± standard error of the mean (SEM) for meters rowed were as follows:

Table 12

Two-Factor ANOVA with Repeated Measures. (N=34)

Workout	NoPC*	PCex*	PCex&post*
Women	3165 ± 224.3	3246 ± 219.2	3038 ± 267.2
Men	3442.8 ± 151.1	3639 ± 142.8	3576 ± 140.9

*: PCex, PCex&post > NoPC where $p \leq 0.05$

CHAPTER FIVE

DISCUSSION

One thing that palm cooling likely worked to combat was thermal stress and its negative effects on cardiac function. When the body begins to overheat, important functions, such as pulmonary capillary wedge pressure and cerebral vascular conductance, are significantly hindered. These effects, as well as several others, cause there to be a decrease in efficiency of the Frank-Starling mechanism (Wilson et al., 2012). In contrast, cooling of the body does the exact opposite; increasing pulmonary capillary wedge pressure and cerebral vascular conductance, while avoiding changes to systolic function (Wilson et al., 2012). While more research is needed to be completed, there is a possibility that palm cooling, as well as other forms of cooling, has the possibility of allowing maximal cardiac efficiency, such as keeping heart rate at a more homeostatic condition while exercising.

In addition to palm cooling lowering heart rate, PC also was shown to significantly lower blood lactate concentrations. In fact, both PCex and PCex&post had significantly lower [BLa-] concentrations than the workout group who did not receive palm cooling. Higher rates of blood lactate accumulation have been well documented to decrease exercise performance. In fact, Hirvonen et al. (1987) concluded that blood lactate accumulation significantly decreases performance and exercise volume in short-term maximal exercise. In addition, with this research study, palm cooling was shown to decrease the rate of blood lactate accumulation and increase the rate of clearance.

In this study, palm cooling produced inter-workout differences for heart rate, blood lactate concentrations, and total work volume. Palm cooling allowed for the palm cooling groups to experience an ergogenic effect, resulting in an increase in overall work volume. Despite the greater exercise volume in the palm cooling groups, the heart rate and blood lactate levels remained lower than the no palm cooling group. It should also be noted that there were not any significant differences between gender (male, female) in any of the variables analyzed.

Study Implications

In multiple studies, applying cold objects against glabrous skin can reduce the accumulation of core body temperature associated with an increase in exercise intensity. However though current results include an ergogenic effect, Table 7 does not suggest greater heat losses through the palmar surface of the hand, as compared to the NoPC condition. Current results support the hypothesis that intermittent palm cooling can be beneficial with exercise, as well as several other practical applications. A meta-analysis by Bongers et al. found that subjects performing aerobic exercise benefitted more from palm cooling than those performing resistance training did.

Although current research on cooling methods seem promising, there is still relatively limited literature on the topic. In fact, the current study that looks at the effects of intermittent palm cooling and its effects on rowing ergometry appears to be the first of its kind. This suggests more research needs to be completed before conclusions can be confidently made, however current research shows there are benefits of using both intermittent palm cooling and cooling in general. There were also studies looking at other forms of cooling, which showed similar benefits. A combination of pre-cooling and mid-cooling has the potential to be the most effective strategy to improve exercise performance. For example, some methods that were examined include a cooling vest, cold-water immersion, cold-water ingestion, and cooling packs (Bongers et al., 2014). Moving forward, comparing different forms of cooling side by side to see which is the most efficient at heat removal should be strongly considered.

Although the results of the study agreed with the original hypothesis, there were still some limitations. One of the most evident limitations was the difficulty of the rowing protocol. With the women's reaching 190W and the men's protocol reaching 250W, several subjects were not able to complete even the familiarization session. For many, this workload was above their maximal exercise capacity. In theory, lowering the exercise intensity would have allowed for more subjects to complete the entire study. If this study were to be replicated, it would be interesting to see the effects of intermittent palm cooling on a lower intensity of exercise. Another limitation that needs to be considered is the method of palm cooling. The gel packs were not applied directly to the palm, but were instead inserted into a glove, resulting in there being a layer of cloth between the glabrous skin and the cooling device. Also, the cooling pack was warmer by the time it was removed, indicative of a large volume of heat exchange.

One specific application for palm cooling outside of structured exercise is within a military setting. Often times, military personnel are located in extremely hot climates while wearing heavy, protective clothing and performing a high level of physical work. Such adverse conditions can lead to a significant decline in performance and result in heat injury. However, administration of palm cooling for military personnel may mitigate this effect. DeGroot et al. found cooling may reduce cardiovascular stress by lowering heart rate 10-25 beats per minute and increase work tolerance time by around 60% (2012). In fact, US Army Ranger Training has incorporated cooling methods as a part of their heat stress mitigation procedures.

Overall, cooling during exercise is becoming a more researched method of increasing exercise performance. However, more research is still necessary to ensure the validity of this method. In addition, there needs to be more research completed that looks at rowing ergometry and responses to palm cooling. Future studies are recommended to compare cooling methods, more practical applications, and the effects of palm cooling on exercise performance in both trained and untrained individuals.

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APPENDICES

APPENDIX A

UofL Institutional Review Boards
IRB NUMBER: 17.1289
IRB APPROVAL DATE: 1/6/2018
IRB EXPIRATION DATE: 1/5/2019

STUDY TITLE: **The impact of palm cooling gloves on metabolic, cardiovascular and thermal responses produced from rowing ergometry.**

INFORMED CONSENT AND RESEARCH AUTHORIZATION

Investigator(s) name, Degree, University Department, & address:
John Caruso PhD, Health & Sport Sci., 2100 S. Floyd St. SAC E105L Louisville 40292
Jessica Stumbo MD, Family & Geriatric Medicine, 1941 Bishop Lane Ste. 900 Louisville 40292
Site(s) where study is to be conducted: SAC East, 2100 S. Floyd St., Louisville 40292
Phone number for subjects to call for questions: 502-852-6648

Introduction and Background Information

You are invited to take part in a research study because you are in good health. Three familiarization sessions will ultimately determine your suitability to participate. The study is being conducted under the direction of John Caruso PhD at the University of Louisville**.** About 35 local subjects will be invited to take part in this research.

Purpose

The purpose of this study is to assess the ability of palm cooling gloves to limit cardiovascular, temperature and metabolic changes produced by exercise done on a rowing ergometer.

Procedures

Your participation in this study will last for approximately 28 days and will consist of six sessions. The first three sessions should last roughly 25 minutes, the final three should last 60 minutes. If you consent to participate, you will have the following procedures while you are in this study.

You must first give informed written consent and be in good health to participate in this project. You should be free of the following; diabetes, exercise-induced asthma, high blood pressure, an abnormally high resting heart rate, heart disease, an overactive thyroid gland, ailments to your muscles and bones, and convulsive disorders. If you are a female of child-bearing age and wish to participate you must also provide proof you are using birth control. Upon giving informed consent and filing out a medical questionnaire that shows you are healthy to participate, you will be admitted into the study by the principal investigator (JF Caruso PhD).

You will make six laboratory visits, beginning with three familiarization sessions, followed by three workouts, each spaced 3-5 days apart. Familiarization sessions will accustom you to wearing the palm cooling gloves during exercise and proper rowing technique. Members of The University of Louisville's Rowing Team will provide proper instruction at familiarization sessions. Also at the first familiarization session, you will provide the following data on your body dimensions: height, weight, leg length, arm length, and torso length. With a cloth measurement tape, all length measurements will be done on the left sides of your body. Familiarization sessions should each last 25 minutes. If you cannot comply with the study requirements, such as if you are unable to maintain proper rowing technique during exercise, you will be withdrawn from the project.

You will put on the gloves prior to warm-ups that will be done at each of their final three visits. While the workouts you do for your final three visits are identical, whether you also have cooling gel packs inserted into your gloves as part of a given workout will be randomly determined by a coin toss. If you do have gel packs inserted into the gloves you are wearing, they will initially have a temperature of 46-48° F and gradually warm, from your body heat, for the 5-6 minute duration they remain inserted.

To begin workouts you will sit quietly for eight minutes. During that time you will put on a heart rate monitor and watch. You will also have an automated blood pressure cuff wrapped around their right arm and temperature sensors placed on your right thigh and forearm, as well as on the palm of your left hand. After eight minutes the following pre-exercise measurements will be obtained: heart rate, blood pressure, blood lactate concentration, skin temperatures of the right thigh and forearm and left hand, as well as ear canal temperature. Once we clean one of your fingertips with an alcohol prep pad, a sterile lancet will puncture skin and 1/20 of a teaspoon of blood will be extracted that will be immediately placed upon a test strip to measure lactate. Ear canal temperature, measured with a hand-held device will estimate the temperature of blood within your head.

After the pre-exercise measurements conclude, you will perform a ten-minute low-intensity (75-90 watt) warm-up on a stationary bicycle. You will continue to wear the heart rate monitor, watch, temperature sensors and blood pressure cuff as you ride the bike. The same pre-exercise measurements will also be obtained after the warm-up. You will then perform the rowing ergometer protocol. The protocol if you are a male is eight two-minute stages done at the following power outputs: 150 watts, 200 watts, 250 watts, and concludes with five consecutive 300 watt stages. If you are a female the protocol is as follows: 100 watts, 130 watts, 160 watts, and concludes with five consecutive 190 watt stages. Regardless of your gender, you will have 30-second rests after the first four stages; thereafter you will receive 60-second rests after each stage. For each two-minute stage, you will have 15 seconds to attain, and then maintain, the designated power output. Failure to do so results in termination of the workout, and your possible withdrawal from the proposed project. You will continue to wear the heart rate monitor, watch and temperature sensors as you row.

During the first four rest periods heart rates and temperatures of the four (right forearm and thigh, left hand, ear canal) sites examined in this study, will be collected. During the first 60-second rest period you will submit to a blood lactate concentration measurement and provide a rate of perceived exertion (RPE) value based on how challenging the workout is up to that point. RPE values will be expressed on a 1 (very easy) to 10 (very hard) scale. During each of the final two 60-second rest periods heart rates and temperatures of the four sites will be collected. After the eighth and final rowing stage, post-exercise measurements immediately commence. At 0-, 5-, 10-, 15- and 20-minutes post-exercise heart rate, blood pressure, blood lactate concentration and temperature measurements at the four sites will be obtained. Also, at 20-minutes post-exercise, you will give another RPE value to rate the rigor of the whole workout.

Potential Risks

Risks are like those seen from most rowing workouts. They include post-workout muscle soreness (which should peak 24-48 hours after workouts conclude and then subside), post-workout fatigue and heart rate increases during exercise. Your risks will be minimized by 1): having members of The University of Louisville's Rowing Team instruct you on proper rowing technique, 2): the ten minute warm-up prior to the rowing ergometer protocol, and 3): the gradual increase in rowing intensities across stages until peak workload values (men: 300 watts, women: 190 watts) are achieved.
The following table details the known risks related to this research and how often they may occur.

Very Common Greater than 50%	Common Between 25% and 50%	Likely Between 10% and 25%	Infrequent Between 1% but and 10%	Rare But Serious Less than 1 %
Muscle soreness from exercise (75%) Post-workout fatigue (75%)			Fainting (1%)	Cardiac arrest (less than 1%)

In addition, you may suffer harms that we have not seen before.

Benefits
There are no perceived direct benefits to you for your project participation. You may not benefit by participating in this study. The information collected may not benefit you directly; however, the information may be helpful to others.

Alternatives
You may choose not to participate.

Research Related Injury
If you incur a research-related injury, please report it to the principal investigator (John Caruso PhD, 852-6648). If you are injured by being in this research study, the study site have not set aside money to pay for treatment of any injury. You and your insurance will be billed for the treatment of these injuries. Before you agree to take part in this research study you should find out whether your insurance will cover an injury in this kind of research. You should talk to the staff about this. In you are injured, there is no money set aside for lost wages, discomfort, disability, etc. You do not give up your legal rights by signing this form. If you think you have a research related injury, please call your doctor.

Payment
You will not be paid for your time, inconvenience, or expenses while you are in this study.

Costs
If you are injured, there may be additional costs to you for participating in this research study.

HIPAA Research Authorization
The Health Insurance Portability and Accountability Act of 1996 (HIPAA) provides federal safeguards for your protected health information (PHI). Examples of PHI are your name, address, and birth date together with your health information. PHI may also include your medical history, results of health exams and lab tests, drugs taken and results of this research study. Your PHI may not be used or shared without your agreement, unless it meets one of the HIPAA exceptions.

State and federal privacy laws protect your health information. In most cases, health information that identifies you can be used or shared by the research team only if you give your permission by signing this form.

If you sign this form your health information will be used and shared to answer the research questions described in this document and to make sure that the research was done correctly. The time period when information can be used or shared ends when all activities related to this study are completed.

Your access to your health information will not be limited during this study.

You do not have to sign this form. If you do not sign this form you may not participate in the study and health information that identifies you will not be shared with the research team.

Site(s) where health information about you will be used or shared for this research:

In our research, the research team will look at and may share information about you and your health. Federal law requires that health care providers and researchers protect the privacy and security of health information that identifies you. We may ask for your health information from the following:

Affiliated Sites:
University of Louisville

Protected health information (PHI) that will be used or shared for research
Consultation reports and questionnaires (your research data will be shared by the project investigators).

Revocation of Research Authorization
You may cancel the permission you have given to use and share your protected health information at any time. This means you can tell us to stop using and sharing your protected health information. If you cancel your permission:

- We will stop collecting information about you.
- You may not withdraw information that we had before you told us to stop.
    - We may already have used it or shared it.
    - We may need it to complete the research.
- Staff may ask your permission to follow-up with you if there is a medical reason to do so.

To cancel your permission, you will be requested to complete a written "Revocation of Research Authorization" form located at the end of this document. You may also obtain a copy from your study doctor, designated personnel or from the Human Subjects Protections Program Office website (https://louisville.edu/research/humansubjects/templates/biomedical-forms).

Confidentiality
Total privacy cannot be guaranteed. We will protect your privacy to the extent permitted by law. If the results from this study are published, your name will not be made public. Once your information leaves our institution, we cannot promise that others will keep it private.

Your information may be shared with the following:

- The University of Louisville Institutional Review Board, Human Subjects Protection Program Office, Privacy Office, others involved in research administration and compliance at the University, and others contracted by the University for ensuring human subjects safety or research compliance
- The local research team
- People who are responsible for research, compliance and HIPAA oversight at the institutions where the research is conducted
- Government agencies, such as:
  - Office for Human Research Protections
  - Office of Civil Rights

Security

The data collected about you will be kept private and secure within a locked filing cabinet inside the principal investigator's office.

Voluntary Participation

Taking part in this study is completely voluntary. You may choose not to take part at all. If you decide not to be in this study, you won't be penalized or lose any benefits for which you qualify. If you decide to be in this study, you may change your mind and stop taking part at any time. If you decide to stop taking part, you won't be penalized or lose any benefits for which you qualify. You will be told about any new information learned during the study that could affect your decision to continue in the study.

Termination

Your study doctor or the study sponsor has the right to stop this study at any point. Your study doctor may take you out of this study with or without your okay. Reasons why this may occur include the study's exercise protocol and/or data collection procedures are deemed to dangerous for you to engage in, thereby exposing you to the risk of physical harm/injury.

Participation in Other Research Studies

You may take part in this study if you are currently in another research study. It is important to let your doctor know if you are in another research study.

Contact Persons

If you have any questions, concerns, or complaints about the research study, please contact John Caruso PhD at 502-852-6648, Jessica Stumbo MD at 502-852-2822 or the Human Subjects Protection Program Office at (502) 852-5188.

Research Subject's Rights

If you have any questions about your rights as a research subject, you may call the Human Subjects Protection Program Office at (502) 852-5188. You may discuss any questions about your rights as a research subject, in private, with a member of the Institutional Review Board (IRB). You may also call this number if you have other questions about the research, and you cannot reach the study doctor, or want to talk to someone else. The IRB is an independent committee made up of people from the University community, staff of the institutions, as well as people from the community not connected with these institutions. The IRB has approved the participation of human subjects in this research study.

Concerns and Complaints

If you have concerns or complaints about the research or research staff and you do not wish to give your name, you may call the toll free number 1-877-852-1167. This is a 24 hour hot line answered by people who do not work at the University of Louisville.

Acknowledgment and Signatures

This informed consent document is not a contract. This document tells you what will happen during the study if you choose to take part. Your signature indicates that this study has been explained to you, that your questions have been answered, and that you agree to take part in the study. You are not giving up any legal rights to which you are entitled by signing this informed consent document. You will be given a copy of this consent form to keep for your records.

Subject Name (Please Print)	Signature of Subject	Date Signed
Printed Name of PersonExplaining Consent Form	Signature of Person Explaining Consent Form (if other than the Investigator)	Date Signed
Printed Name of Investigator	Signature of Investigator	Date Signed

List of Investigators:	Phone Numbers:
John Caruso PhD	852-6648
Jessica Stumbo MD	852-2822

STUDY TITLE: The impact of palm cooling gloves on metabolic, cardiovascular and thermal responses produced from rowing ergometry.

REVOCATION OF AUTHORIZATION FOR USE AND DISCLOSURE OF YOUR HEALTH INFORMATION FOR RESEARCH

Return To:

PI Address: 2100 S. Floyd Street, E SAC 105L Louisville KY 40292 PI Phone: 502-852-6648	OR	Institutional Review Board MedCenter One, Suite 200 501 E. Broadway Louisville, KY 40202

Do not sign this letter unless you are withdrawing from this research. You will be sent confirmation that this notice was received.

To Whom It May Concern:

I would like to discontinue my participation in the research study noted above. I understand that health information already collected will continue to be used as discussed in the Authorization I signed when joining the study.

Your options are (***choose one***):

☐ **Withdraw from Study & Discontinue Authorization:**
Discontinue my authorization for the future use and disclosure of protected health information. In some instances, the research team may need to use your information even after you discontinue your authorization, for example, to notify you or government agencies of any health or safety concerns that were identified as part of your study participation.

☐ **Withdraw from Study, but Continue Authorization:**
Allow the research team to continue collecting information from me and my personal health information. This would be done only as needed to support the goals of the study and would not be used for purposes other than those already described in the research authorization.

______________________________ ______________
Printed Name and Signature of Subject — Date Signed

______________________________ ______________
Signature of Subject's Legal Representative (if subject is unable to sign) — Date Signed

______________________________ ______________
Printed Name of Subject's Legal Representative — Birthdate of Subject

____
Relationship of Legal Representative to Subject

______________________________ ______________
Subject's Address — Subject's Phone Number

Optional:
I am ending my participation in this study because:

____

APPENDIX B

NAME ____

HEIGHT ______________________

TOTAL LEG LENGTH ______________________

TOTAL ARM LENGTH ______________________

TOTAL TORSO LENGTH ______________________

WEIGHT ______________________

BF% ______________________

FFM ______________________

APPENDIX C

MEDICAL QUESTIONNAIRE

Please answer the following questions carefully, placing a check next to the most appropriate response. Please consult the witness if any of the following terms is unfamiliar to you. As a potential subject do you have the following:

	YES	NO
diabetes	____	___
exercise-induced asthma	____	___
high blood pressure	____	___
rapid heart beat	____	___
insufficient blood flow to the heart	____	___
abnormal heart beat patterns	____	___
overactive thyroid gland	____	___
musculoskeletal ailments to either leg	____	___
convulsive disorders	____	___
Dairy product allergies	____	___
enzyme deficiencies (Mc Cardle's disease)	____	___

I understand the investigative team will not screen for blood disorders; their reason for obtaining blood samples is to measure markers of muscle damage related to exercise. I have answered the above statements correctly:

____________________________ ____________________
Signature Date

____________________________ ____________________
Witness Date

APPENDIX D

AVERAGE ROOM TEMP: _____ ^{O}C

NAME ____________________ DATE____________ WORKOUT (circle one): NoPC PCex PCex&post

PRE-EX. HR _______ BP_____/_______ RFA T _______ RT T ________ LH T ________ AUD T _____ [BLa$^-$] ________

POST-BIKE: HR _______ BP_____/_______ RFA T _______ RT T ________ LH T ________ AUD T _____

DRAG SETTINGS : MEN = 10 WOMEN = 5

STAGE	PACE	METERS	HR	RFA T	RT T	LH T	AUD T	RMS	
____	____	____	____	____	____	____	____	____	(45 seconds rest-insert)
____	____	____	____	____	____	____	____		(45 seconds rest)
____	____	____	____	____	____	____	____		(45 seconds -remove)
____	____	____	____	____	____	____	____		(45 seconds rest)
____	____	____		RPE _____		[BLa$^-$] _____			(60 seconds rest-insert)
____	____	____	____	____	____	____	____		(60 seconds rest)
____	____	____	____	____	____	____	____		(60 seconds-remove)
____	____	____	____	____	____	____	____	____	(**0 POST** values-insert)

POST:	HR	BP	[BLa$^-$]	RFA	RT	LH	AUD	RPE
5 (remove)	____	_____/_____	____	____	____	____	____	
10 (insert)	____	_____/_____	____	____	____	____	____	
15 (remove)	____	_____/_____	____	____	____	____	____	
20	____	_____/_____	____	____	____	____	____	____

CURRICULUM VITA

Ian O'Brien

ian.obrien@louisville.edu

Education

Master of Science, Anticipated April 2019
Concentration: Clinical Exercise Physiology with Thesis
Outstanding Graduate Student Award – Exercise Physiology Recipient
University of Louisville; Louisville, KY

Bachelor of Science, May 2017
Major: Exercise Science; Minor: Nutrition
University of Wisconsin – La Crosse; La Crosse, WI

Work Experience

Graduate Assistant, August 2017 – Current
University of Louisville, Department of Health and Sport Sciences, Exercise Physiology Program, Louisville, KY

- Teaching Assistant - Assist faculty in administering exercise tests and maintaining exercise physiology laboratory
    - HSS 184: Healthy Lifestyles, 1 section
    - HSS 202: Human Anatomy & Physiology, 2 sections
    - HSS 387: Biomechanics, 2 sections
    - HSS 388: Principles of Athletic Conditioning, 3 sections
    - HSS 391: Human Anatomy and Physiology II Lab, 4 sections
    - HSS 394: Foundations of Exercise Physiology, 2 sections
    - HSS 396: Lab Methods in Fitness Evaluation, 3 sections
    - EXP 601: Lab Methods in Exercise Physiology, 2 sections
- Research Assistant - Assist faculty in collecting research data from human subjects, analyzing data, and preparing manuscripts and presentations for university, local, and peer-reviewed audiences
    - Ann M. Swank Exercise Physiology Lab, Student Activities Center, University of Louisville, 2100 S. Floyd St., Louisville, KY, 40292, August 2017 - Current

Wellness Coach, January 2018 – May 2018
Northeast Family YMCA, Louisville, KY

- Conducted wellness appointments to assist new members in smoothly transitioning into using the fitness center

- Supervised weight room and fitness center to ensure members were using machines properly and performing movements with correct technique

Exercise Physiology Intern, May 2017 – August 2017
Gundersen Lutheran Hospital, La Crosse, WI

- Worked in Phase II Cardiac Rehabilitation with patients who endured various types of heart surgeries
- Assisted with diagnostic stress tests by preparing patients for 12-lead EKG and performing exercise/resting blood pressure measurements
- Taught education classes for cardiac rehabilitation patients covering topics such as cardiac anatomy, stress management, and nutrition

Resident Assistant, August 2015 – May 2017
University of Wisconsin – La Crosse, La Crosse, WI

- Served as a resource to 34 culturally diverse college students
- Acted as a role model both academically and personally
- Worked to educate students on making healthy choices with regards to alcohol, drugs, exercise, etc.

Adult Physical Fitness Program Assistant, August 2016 – May 2017
University of Wisconsin – La Crosse, La Crosse, WI

- Provided a personalized exercise program for a 52-year-old male with a physical and cognitive disability
- Worked to improve the participant's gross motor skills, cardiovascular endurance, muscle strength, and muscle endurance
- Used personal judgement to progress the participant through the exercise plan to reach his semester-long goals

Strength & Conditioning Coach, May 2015 – August 2016
Pius XI Catholic High School, Milwaukee WI

- Designed workout programs for over 100 student-athletes
- Motivated students to achieve maximum results
- Ensured athletes lifted with proper technique

Research Projects

1. The impact of palm cooling gloves on metabolic, cardiovascular, and thermal responses produced from rowing ergometer, conducted data collection and analysis, February 2018 – Current
2. Flexibility and Jump Performance in Previously Injured Knees, conducted data collection and analysis, January 2017 – May 2017
3. Heart rate reserve versus talk test: is there a similar training effect?, performed testing, observed data collection, January 2016 – July 2016

Manuscripts in Preparation

1. **O'Brien, I.T.**, Caruso, J. F., King, K. M., & Pantalos, G. M., The impact of palm cooling gloves on metabolic, cardiovascular, and thermal responses produced from rowing ergometer, Master of Science Thesis

Peer-Reviewed Research Presentations

1. W.D. Gray, **I.T. O'Brien**, A.E. Kozerski, A.C. Vanhoover, C.B. McEnroe, and J.F. Caruso. Electrolyte-based sport drinks: effect on steady state exercise against progressively higher workloads. American College of Sports Medicine's Annual Meeting. Orlando, Florida. May 30th, 2019.
2. **O'Brien, I.T.**, Chen, L., Vargas, L.J., Vanhoover, A.C., McEnroe, C.B., Kozerski, A.E., & Caruso, J.F. *Ergogenic, Perceptual and Metabolic Responses to Palm Cooling.* Poster presentation for Southeast American College of Sports Medicine (ACSM) Conference, Greenville, South Carolina.
3. Vanhoover, A.C., McEnroe, C.B., Kozerski, A.E., **O'Brien, I.T.**, & Caruso, J.F. *Electrolytes Added to a Carbohydrate-Based Drink: Effect on Exercise Done Against Progressively Higher Workloads.* Poster presentation for Southeast American College of Sports Medicine (ACSM) Conference, Greenville, South Carolina.
4. McEnroe, C.B., Chen, L., Vargas, L.J., **O'Brien, I.T.**, Kozerski, A.E., Vanhoover, A.C., & Caruso, J.F. *Dwell Times from a High-Speed Exercise Intervention as a Correlate to Calcaneal Accretion.* Poster Presentation for Southeast American College of Sports Medicine (ACSM) Conference, Greenville, South Carolina.
5. McEnroe, C.B., Davison, S.W., Bai, L., Vargas, L.J., **O'Brien, I.T.**, Kozerski, A.E., Vanhoover, A.C., Carter, K.A., & Caruso, J.F. *Dwell time as a correlate to calcaneal accretion produced by chronic high-speed resistive exercise.* Poster Presentation for the National Aeronautics and Space Administration's (NASA) Annual Human Research Program Investigators Workshop, Houston, Texas
6. Chen, L., Selimovic, E.A., Daunis, M., Bayers, T.A., Vargas, L.J., **O'Brien, I.T.**, McEnroe, C.B., Kozerski, A.K., Vanhoover, A.C., Gray, W.D., & Caruso, J.F. (in review). Musculoskeletal outcomes from chronic high-speed high-impact resistive exercise. *Gravitational and Space Research,* 1-28
7. Gray, W.D., **O'Brien, I.T.**, Kozerski, A.E., Vanhoover, A.C., McEnroe, C.B., & Caruso, J.F. (in review). *Electrolyte-based sport drinks: Effect on steady state exercise against progressively higher workloads.* Poster Presentation for American College of Sports Medicine (ACSM) Annual Meeting, Orlando, Florida
8. Parmar P.J., Davison S.W., Bai L., Vargas L.J., **O'Brien I.T.**, McEnroe C.B., Carter K.A., and Caruso J.F. Performance-based correlates to calcaneal accretion produced by chronic high-speed resistive exercise. Annual Conference of The American Society for Gravitational and Space Research. Rockville, Maryland. November 2018

9. J.F. Caruso, **I.T. O'Brien**, A.E. Kozerski, C.B. McEnroe, A.C. Vanhoover, W.D. Gray. Robotic exoskeletons as exercise countermeasures for manned space flights. Presented to Sandalwood Engineering and Ergonomics. Louisville, KY. October 17th, 2018
10. R.E. Mueller, L. Bai, L.J. Vargas, **I.T. O'Brien**, C.B. McEnroe, J.F. Caruso. Intermittent Palm Cooling's Impact on Resistive Exercise Performance. Spring Research Conference. Louisville Kentucky, March 24th, 2018.

Invited Presentations

1. Caruso, J.F., **O'Brien, I.T.**, Kozerski, A.E., Vanhoover, A.C., & Gray, W.D. (October 2018). Robotic exoskeletons as exercise countermeasures for manned space flights. Presented to Sandalwood Engineering and Ergonomics, Louisville, Kentucky.
2. **O'Brien, I.T.** (October 2018). Introduction to Electrocardiography Lecture. Presented to University of Louisville graduate students registered for EXP 601: Lab Methods in Exercise Physiology, Louisville, Kentucky.
3. **O'Brien, I.T.** (February 2018). Cardiac Anatomy and Physiology Lecture. Presented to University of Louisville undergraduate students registered for HSS 202: Human Anatomy & Physiology, Louisville, Kentucky.

Professional Memberships

1. American College of Sports Medicine (ACSM) member, September 2017 – Current

Committee Participation

1. University of Louisville, Department of Health and Sport Sciences Faculty Search Committee, August 2018 – November 2018
2. University of Louisville, Department of Health and Sport Sciences Student Engagement Committee Student Engagement Committee, July 2018 – Current
3. University of Louisville, Graduate Student Council Representative for Department of Health and Sport Sciences, August 2017-May 2018

Certifications

1. CPR/AED/First Aid Certification, August 2014 – Current
2. USA Weightlifting Level 1 Sports Performance Coach, December 2014 – Current
3. Advanced Cardiac Life Support (ACLS) – Expected May 2019