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The Effects of a Moisture-Wicking Fabric Shirt on the Physiological Responses During Acute Exercise in the Heat

Kimberly Wigboldy
Western Michigan University

THE EFFECTS OF A MOISTURE-WICKING FABRIC SHIRT ON THE PHYSIOLOGICAL RESPONSES DURING ACUTE EXERCISE IN THE HEAT

by

Kimberly Wigboldy

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Thesis Committee:

Christopher C. Cheatham, Ph.D., Chair
Carol Weideman, Ph.D.
Amy Gyorkos, M.S.

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The purpose of this study is to investigate the effects that a form fitted, moisture-wicking fabric shirt, promoted to have improved evaporative and ventilation properties, has on the thermoregulatory, physiological and perceptual response during moderate intensity exercise in the heat for an extended duration of exercise of 90 minutes. Ten healthy subjects (7 males, 3 females), completed two heat stress tests consisting of 20 minute seated rest in a neutral environment (24°C, 60% RH), 30 minute seated rest in a hot environment (33°C, 60% RH), and 90 minutes of exercise (50% VO_{2peak}) on a magnetically-braked cycle ergometer in a hot environment (33°C, 60% RH). One stress test was conducted with the subject wearing a short sleeved synthetic polyester shirt (81% polyester and 19% elastane) (UA) while the other was conducted with the subject wearing a short-sleeved 100% cotton shirt (COT). During the UA condition rectal temperature was not significantly different compared to the COT condition during the heat stress test, or in skin temperature other than the tricep. The UA condition showed no significant difference in sweat rate compared to the COT condition.

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First and foremost, To God be all the glory and honor and His name be praised. God has given me the ability to accomplish this task and I use all of the gifts that He has given me solely to bring honor and glory to his name. He has been faithful thus far and will continue to be faithful.

I would like to thank my family for their continuous love, encouragement, and support all these years. Mom, Dad, Kyle, Joanna, Crystal, and Mark you all have been so amazing and I thank God every day for you.

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Finally, I thank my husband Kyle. I am who I am because you loved me and make me better every day. I love you with all of my heart.

-Kimberly Wigboldy

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INTRODUCTION

Core temperature increases with the onset of exercise. This increase in core temperature is due to the production of heat caused by the contraction of muscles and the metabolic inefficiency at the cellular level. The body attempts to maintain core temperature by increasing heat loss through the dissipation of the heat produced from the muscular activity. The mechanisms used to compensate for the increased core temperature are conduction, convection, radiation, and evaporative heat loss (i.e. sweating). Heat is transferred to the periphery through the vasodilation of blood vessels at the surface of the skin.

Environmental factors such as ambient temperature, relative humidity and wind velocity play a large role in this migration of heat from the core of the body to the periphery. As the ambient temperature increases, the nervous system senses this change, which causes the blood vessels to dilate, increasing blood flow to the skin surface. During exercise, however, the working muscles demand increased blood flow and oxygen delivery to produce power. Therefore, when exercising in hot conditions, the capacity to transfer heat through radiation and convection becomes minimized due to a reduction in the temperature gradient between the dilated blood vessels of the skin and the surrounding environment (27). As a result, the primary form of heat dissipation and primary mechanism for maintaining thermal balance is through the evaporation of sweat (7).

Activation of the eccrine sweat glands results in the production of sweat, which is secreted onto the skin surface, thereby promoting heat loss by evaporation of the water content of the sweat (27). Normal sweating rates during exercise can be anywhere between 1.0 – 2.5 $L \cdot hr^{-1}$, however, when exercising in the heat, rates can increase to $\geq 2.5\ L \cdot hr^{-1}$ (26). Sweat is only a cooling method if it evaporates. The potential for evaporative heat loss is determined by the water vapor pressure gradient between the skin and the environment and the movement of air over the skin. Therefore, if the relative humidity is low or the air is dry, the sweat will evaporate quickly. Conversely, if the relative humidity is high, the evaporation will be hindered and sweat will accumulate with little loss of body heat (8). Consequently, exercise in a hot, humid environment may result in critical heat load on the body.

Environmental heat stress combined with high intensity exercise can result in three different exercise related injuries such as heat cramps, heat exhaustion, and heat stroke (27). The high core and skin temperatures are a result of the narrowing core-to-skin temperature gradient which increases cardiovascular strain and reduces peak oxygen uptake (7). Unfortunately, the demands of dynamic exercise at intensities up to maximum oxygen consumption are limited by blood flow. Blood flow to active muscle, including the heart, is required to meet the energetic demands for muscle activity, while blood flow to the skin is required to meet the demands of temperature regulation. Reduced muscle blood flow will limit the intensity and duration of exercise, while reduced skin blood flow will limit the disposal of heat resulting in adverse effects of elevated internal temperature, including that of the central nervous system (16,18,24).

Reduced blood flow causes an increased cardiovascular strain and when combined with high intensity exercise and high ambient temperatures there is a decline in stroke volume, cardiac output, muscle blood flow, and oxygen delivery, reducing the peak oxygen uptake (VO_{2peak}) (15,18,26). Hyperthermia appears to be the factor in fatigue and heat related illnesses during exercise. Balancing heat production as well as heat loss through elevated blood flow becomes essential for the athlete to safely exercise. One distinct method utilized in an attempt to increase health safety and improve heat tolerance is the employment of clothing with properties that positively augment heat dissipation.

The exchange of air between the clothing microclimate and the external environment is an important determinant of thermal comfort. An important aspect of thermal comfort is the ability to dissipate heat by sweat evaporation. A more suitable way of alleviating heat strain caused by heat buildup in the microclimate (i.e. area between the skin and the clothing) may be to increase the rate of air exchange between the clothing and the environment (14,27,29).

Many modern breathable fabrics or absorption and quick drying fabrics have been introduced to the market. Manufacturers claim the fabrics improve evaporative characteristics and provide maximum thermophysiological comfort for wearers. Not only should one consider the properties of clothing fabric but also the use of suitable designs on the clothing. Wool and cotton fabrics tend to absorb water making them subpar for water dissipation and moisture transfer (9). Compared to wool or cotton garments, synthetic polyester fabric garments are said to have superior moisture wicking qualities due to increased fabric permeability which may potentially improve evaporative heat loss and lead to a lower core temperature (13).

Researchers have investigated, but have not have concluded for certain, whether the synthetic polyester garments contribute to a lower rectal temperature during exercise. Companies market the clothing by claiming it will keep the athlete cool and dry during exercise, however, it still remains uncertain as to whether the fabric type has any significant effect on the physiological responses during exercise.

A study with eight highly trained athletes performed by Gavin et al. revealed no alteration in physiological, thermoregulatory, or comfort sensation responses during moderate exercise in a warm environment with clothing conditions consisting of a short sleeved cotton and synthetic polyester shirt. Gavin et al. hypothesized that subjects wearing synthetic polyester garments made from a fabric with improved evaporative characteristics would show less thermal stress than that of more traditional cotton fabrics. However, the researchers suggested that the exercise intensity of 70% maximal oxygen consumption (VO_{2peak}) for 30 minutes was not significant enough to stress the highly trained subjects (13).

Similarly, a recent study by Brazaitis et al. attempted to build on the study performed by Gavin et al. by suggesting a higher exercise intensity would place increased cardiovascular strain on the subjects resulting in significant differences in responses between both conditions. Brazaitis et al. hypothesized that higher exercise intensities in the heat should induce higher sweat rates, leading to greater sweat accumulation and greater thermoregulatory stress, inferring that these factors may be affected by the different fabric materials (3). Brazaitis et al. also used two types of garments, long-sleeved traditional cotton t-shirt and a long-sleeved polyester shirt promoted to have improved evaporative characteristics. The results from the study showed a better sweat evaporation and reduced sweat sorption in the subjects wearing the polyester garments, yet found no differences in the two garments for any subject comfort responses or thermophysiological responses.

A previous study completed in our laboratory (11) examined similar hypotheses. The subjects in this study were asked to exercise for 45 minutes at 50% of their VO_{2peak} in a hot environment of 33°C and 60% relative humidity (RH). The results showed that rectal temperature was lower while the subjects were wearing the polyester shirt between 30-45 minutes of exercise. While the difference was statistically significant, it was not clinically significant. Based on the results of the DeSousa study, it is unknown it the difference between the two conditions would be clinically significant if the duration of exercise was increased. Therefore, the purpose of this study was to investigate the effects that a form fitted, moisture-wicking fabric shirt, promoted to have improved evaporative and ventilation properties, has on the thermoregulatory, physiological and perceptual response during moderate intensity exercise in the heat for an extended duration of exercise of 90 minutes.

CHAPTER II

RESEARCH METHODS

Subjects and Design

Ten subjects (7 males, 3 females) (Age: 25 $\pm$ 1.8 yrs, Height: 173.4 $\pm$ 19.2 cm, VO_{2max}: 47.0 $\pm$ 4.24 $mL \cdot kg^{-1} \cdot min^{-1}$, Body Weight: 78.8 $\pm$ 14.0 kg, Body Mass Index: 26.2 $\pm$ 2.1 $kg \cdot m^{-2}$, Body Fat %: 14.4 $\pm$ 5.5%) participated in this study. All subjects were healthy, free of disease and medication use, not obese (Body Mass Index < 30.0 $kg \cdot m^{-2}$), not pregnant, and non-smokers. The study was approved by the Human Subjects Institutional Review Board at Western Michigan University. All subjects read and signed the informed consent prior to participation in the study.

Each subject visited the Human Performance Research Laboratory at Western Michigan University three times. During the first visit, anthropometrical measurements were obtained and each subject performed a maximal graded exercise test on a cycle ergometer. On the second and third visits, a heat stress test was performed. One heat stress test was conducted with the subject wearing a 100% cotton short sleeved t-shirt (COT) while the other heat stress test was conducted with the subject wearing a short sleeved, commercially available, synthetic shirt (81% polyester and 19% elastane; males: UnderArmour style #

1236224; females: UnderArmour style # 1228321). The females also wore a synthetic sports bra (UnderArmour style # 1233406) (UA). The order of the heat stress test visits was counter-balanced. Each subject finished the study in an eight week time period.

Prior to each visit, subjects were instructed to refrain from alcohol, caffeine, and physical activity during the final 24 hours leading up to the visits to the laboratory.

Research Procedures

Anthropometric Assessment / Graded Exercise Test

Upon arrival to the laboratory on the first day, all research procedures were explained to the subject and informed consent was obtained. Each subject then completed a health history questionnaire in order to confirm that he/she was healthy, free of disease and medication use, not pregnant, and classified as "low-risk" according to the American College of Sports Medicine (ACSM) guidelines (24).

Anthropometric measurements were assessed on each subject. Weight and height were measured via a digital scale and stadiometer, respectively. Skinfold thickness was measured at seven sites (triceps, abdomen, thigh, calf, suprailiac, chest, subscapular) using Lange skinfold calipers (Lange Caliper, Beta Technology, Santa Cruz, CA). Each site was measured in triplicate with the mean of the three measurements used as the skinfold thickness. The Jackson & Pollock 7-site equation was used to calculate body density from the skinfold assessment and the Brozek equation was used to calculate percent body fat from body density (5,20).

After the anthropometric measurements were assessed, the subject then completed a graded exercise test on a magnetically-braked cycle ergometer (Corival, Lode B.V., Groningen, Netherlands) to determine the VO_{2peak}. Prior to all of the graded maximal tests, the metabolic cart was calibrated using a 3-Liter syringe and gases of known concentration. Each subject was then fitted with a nose clip and a mouthpiece for the collection of expired respiratory gases using the metabolic measurement cart (TrueOne 2400, ParvoMedics, Sandy, UT) and a telemetry heart rate (HR) monitor (Polar USA, Lake Success, Long Island, NY). Lastly, each subject was instructed on using the Borg Ratings of Perceived Exertion (RPE) (6-20) chart (1).

Once instrumentation was completed, the graded exercise test began. The graded test started at 60 Watts for the males and 40 Watts for the females for the first two minutes of the test, and the intensity was raised by 20 Watts for both male and female participants every minute until exercise failure was reached. VO_{2peak} was defined as the greatest 30 second average during the test.

Heat Stress Tests

The second and third visits to the laboratory were for the heat stress tests (UA and COT). The order of the stress tests was counter-balanced. The female participants completed the heat stress tests during the follicular phase (i.e. Days 1-8 after menses) of the menstrual cycle due to its potential effect on core temperature (21).

Upon arriving to the laboratory, each subject was instructed to void and nude body weight was measured. Each subject was then instructed to insert a rectal temperature probe (Physitemp Instruments Inc., Clifton, NJ) 13 centimeters past the anal sphincter. The subject's shirt (for females the sports bra was included in this measurement) was weighed (LC 101, Omega Engineering Inc., Stamford, CT) then given to the subject. After insertion of the rectal probe, skin thermocouples (Physitemp Instruments Inc., Clifton, NJ) were attached with waterproof tape (Hy-tape, Hytape International Inc., Patterson, NY) to the right side of the body at the chest, tricep, thigh, and calf for determination of mean skin temperature (MT_{sk}) (24). Rectal and skin thermocouples were interfaced to a data acquisition system (Thermes USB, Physitemp Instruments Inc., Clifton, NJ) interfaced to a PC computer. An automated resistance hygrometry system (6) was utilized for the determination of sweat volumes and rates (QSweat, WR Medical Electronics Co., Stillwater, MN). Ventilated capsules (0.878 sq cm) were secured with rubber straps to the upper chest, upper back, thigh and calf, and then interfaced to a PC computer for the continuous collection of sweat rate and volume. A telemetry HR monitor was strapped around the subject's chest for the continuous measurement of heart rate. Lastly, the subject put the appropriate shirt for the trial over the probes to hold them into place before he or she was seated on a lounge chair in a semi-recumbent position.

The subject sat quietly in the lounge chair for 10 minutes in a thermo-neutral environment (24°C, 60% RH) (24°CBASE), followed by 30 minutes of seated rest in a heated environment (33°, 60% RH) (33°CBASE). Rectal temperature (T_{re}), skin temperatures and sweat rate (SR) were measured continuously throughout the tests. Thermal sensation (12), sweating sensation (13), RPE (1), and HR were assessed and recorded during the last 5 minutes of 24°CBASE and 33°CBASE.

After the completion of the 33°CBASE, the subject was then transported and fitted on the cycle ergometer to begin the exercise portion of the trial. This exercise portion of the trial consisted of 90 minutes of cycling at 50% of VO_{2peak} in 33°C air and 60% RH (33°CEX). For the first 15 minutes of the first exercise stress test, the subject's VO_2 was monitored using a metabolic cart. During minutes 5-7 of exercise, if the subject was not within 5% of the desired exercise intensity (50%VO_{2peak}), the workload was adjusted. This workload was then replicated during the subject's second trial. T_{re}, skin temperatures, and SR were measured continuously during exercise. HR, RPE, thermal sensation, and sweat sensation were recorded every 5 minutes. Water intake was monitored and measured. Each subject was permitted to consumer water *ad libitum* during the first heat stress test and that amount was replicated for the second test to control the hydration status between the two tests.

After the completion of each test, the subject's upper body garments were immediately placed in one freezer bag, sealed and weighed. All probes and capsules were removed from the subject. The subject was then instructed to towel off and weigh himself/herself nude.

Calculation of Sweat Volumes and Rates

Cumulative sweat volume was calculated as the sum of sweat produced in μL during all stages of the test. Sweat rate was calculated as a per minute ($\mu L \cdot min^{-1} \cdot cm^{-2}$) value over the last 5 minutes of 24°CBASE and 33°CBASE and each 10 minute interval of 33°CEX. Total body sweat loss was calculated as the difference between pre and post body weight, plus the amount of water consumed during the trial.

Statistical Analysis

The differences between the COT and UA apparel t-shirts (and under garments for the female participants) for the dependent variables were analyzed using a two-way analysis of variance (ANOVA) with repeated measures. The factors in the analysis were clothing (COT vs. UA) and time with both being repeated measures. In the case of a significant main effect for time or interaction, post-hoc tests were performed using a simple effects analysis with the Bonferroni adjustment.

To analyze the difference between the COT and UA apparel shirts (and under garments for the female participants) for shirt weight and whole-body sweat volume and rate, a paired samples t-test was used.

The level of statistical significance was established *a priori* as $P < 0.05$. The SPSS statistical package (v 20.0) was used for data analysis. Data is presented as means (M) $\pm$ standard deviations (SD).

CHAPTER III

RESULTS

Exercise Intensity

There was no significant difference in workload between the clothing conditions. Mean exercise intensity ($L \cdot min^{-1}$) was 1.92 ± 0.41 ($51.3 \pm 1.7\%$ VO_{2peak}).

Temperature Variables

Rectal Temperature

Figure 1 displays the response in T_{re} over time in the COT and UA clothing conditions. The main effect for clothing was not significant (COT: 37.77 ± 0.35, UA: 37.72 ± 0.25 °C; $P = 0.779$). As expected, there was a significant main effect for time ($P < 0.001$). The clothing-by-time interaction was not significant ($P = 0.997$).

Mean Skin Temperature

Figure 2 displays the response in MT_{sk} over time in the COT and UA clothing conditions. The main effect for clothing was not significant (COT: 35.56 ± 0.42, UA: 35.32 ± 0.45 °C; $P = 0.091$). As expected, there was a significant main effect for time ($P < 0.001$). The clothing-by-time interaction was not significant ($P = 0.631$).

Chest, Tricep, Thigh, and Calf Skin Temperature

Figure 3 displays the response in skin temperature at the chest (T_{chest}), tricep (T_{tricep}), thigh (T_{thigh}), and calf (T_{calf}) over time in the COT and UA clothing conditions. The main effect for clothing was significant for T_{tricep} (COT: 35.95 ± 0.64, UA: 35.31 ± 0.48 °C; $P = 0.015$). The main effect for clothing was not significant for T_{chest} (COT: 35.64 ± 0.75, UA: 35.42 ± 0.80 °C; $P = 0.590$), T_{thigh} (COT: 35.49 ± 0.63, UA: 35.31 ± 0.82 °C; $P = 0.541$), and T_{calf} (COT: 35.21 ± 0.77, UA: 35.38 ± 0.60 °C; $P = 0.195$), As expected, there was a significant main effect for time for T_{chest}, T_{tricep}, T_{thigh}, and T_{calf} ($P < 0.001$). The clothing-by-time interaction was not significant for T_{chest} ($P = 0.997$), T_{tricep} ($P = 0.797$), T_{thigh} ($P = 0.902$), and T_{calf} ($P = 0.761$).

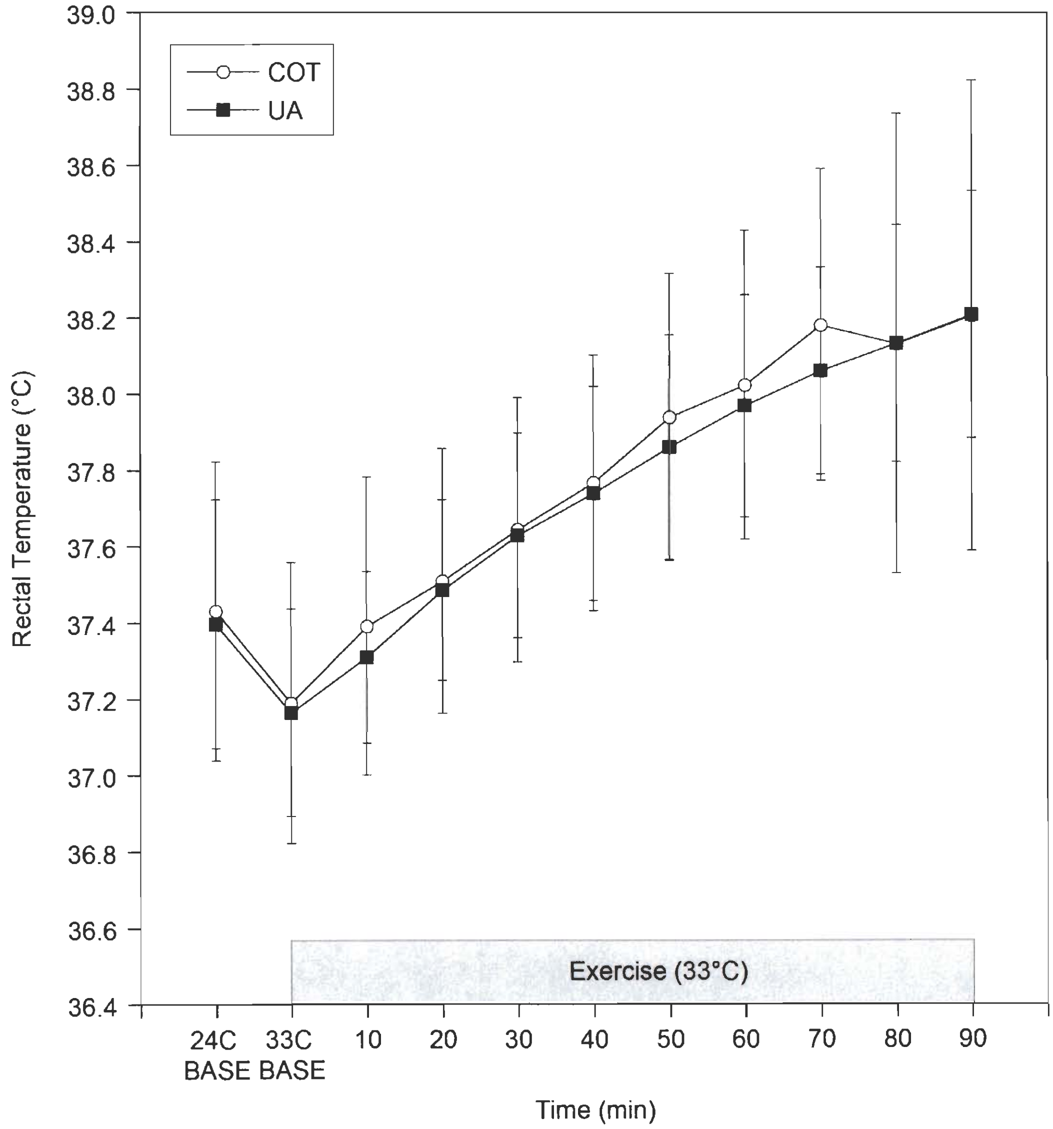

Figure 1. Rectal temperature response during heat stress tests (M $\pm$ SD) (Clothing x Time: P = 0.997)

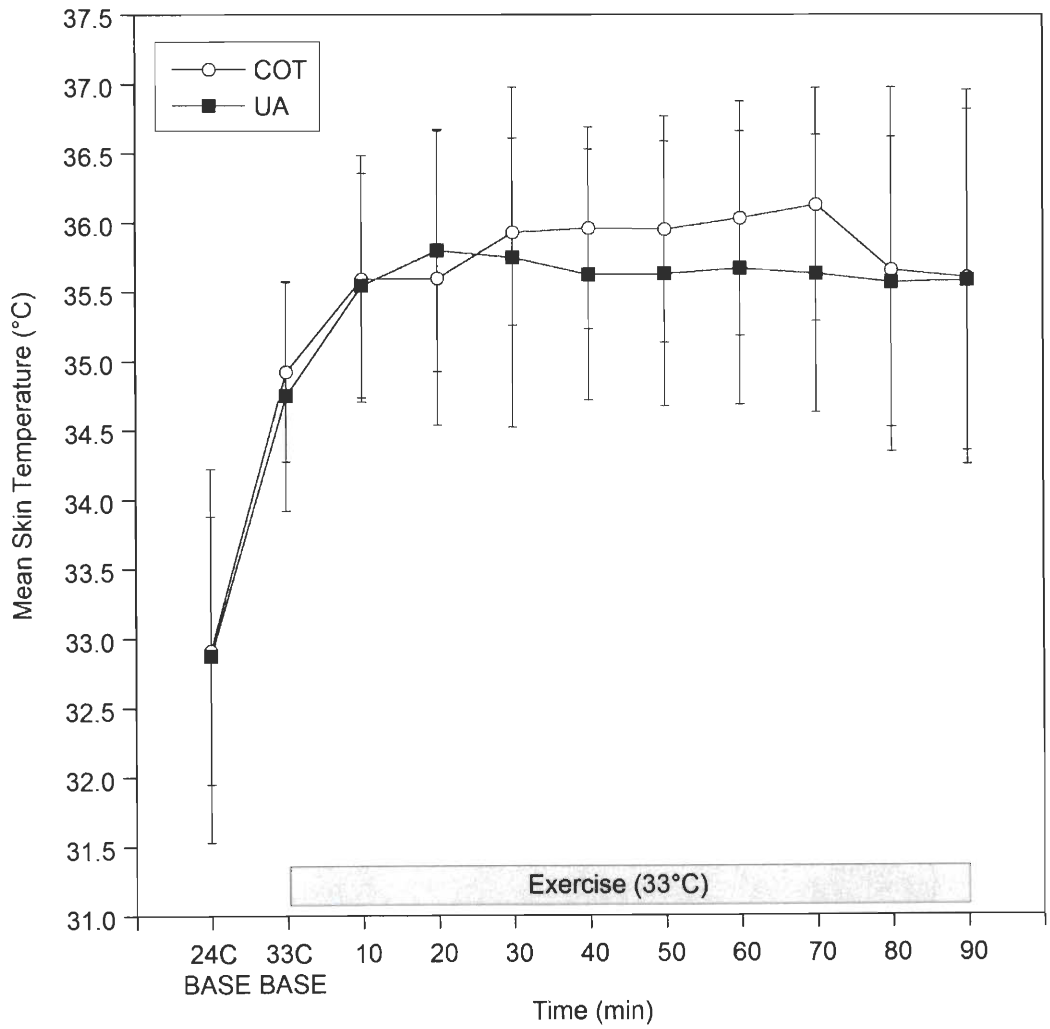

Figure 2. Mean skin temperature response during heat stress tests (M ± SD) (Clothing x Time: P = 0.631)

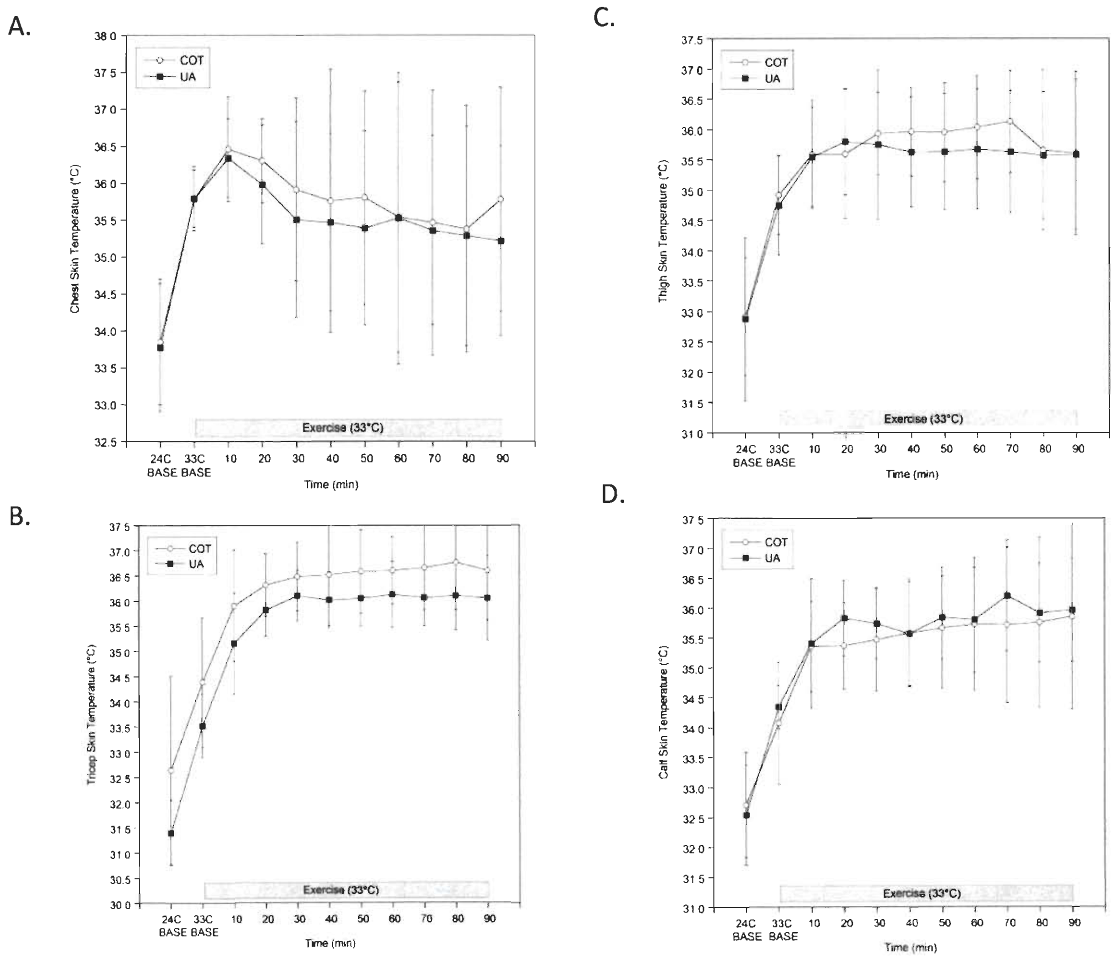

Figure 3. Chest (A), tricep (B), thigh (C), and calf (D) skin temperature responses during heat stress tests (M $\pm$ SD) (Clothing x Time; chest: P=0.997; tricep: P=0.797; thigh: P= 0.902; calf: P= 0.761)

Sweat Variables

Chest, Back, Thigh, and Calf Average Sweat Rate

Figure 4 displays the response in average sweat rate (SR) over time in the COT and UA clothing conditions. The main effect for clothing was not significant with respect to average sweat rate at the chest (COT: 1.10 ± 0.43, UA: 0.89 ± 0.43 $\mu L \cdot min^{-1} \cdot cm^{-2}$; P = 0.089), back (COT: 0.86 ± 0.17, UA: 0.80 ± 0.36 $\mu L \cdot min^{-1} \cdot cm^{-2}$; P = 0.607), thigh (COT: 0.61 ± 0.36, UA: 0.61 ± 0.29 $\mu L \cdot min^{-1} \cdot cm^{-2}$; P = 0.968), and calf (COT: 0.72 ± 0.31, UA: 0.71 ± 0.28 $\mu L \cdot min^{-1} \cdot cm^{-2}$; P = 0.871). As expected, there was a significant main effect for time for average sweat rate, (P < 0.001) at the chest, back, thigh, and calf. The clothing-by-time interaction was not significant at the SR_{chest} (P = 0.169), SR_{back} (P = 0.962), SR_{thigh} (P = 0.403), and SR_{calf} (P = 0.944).

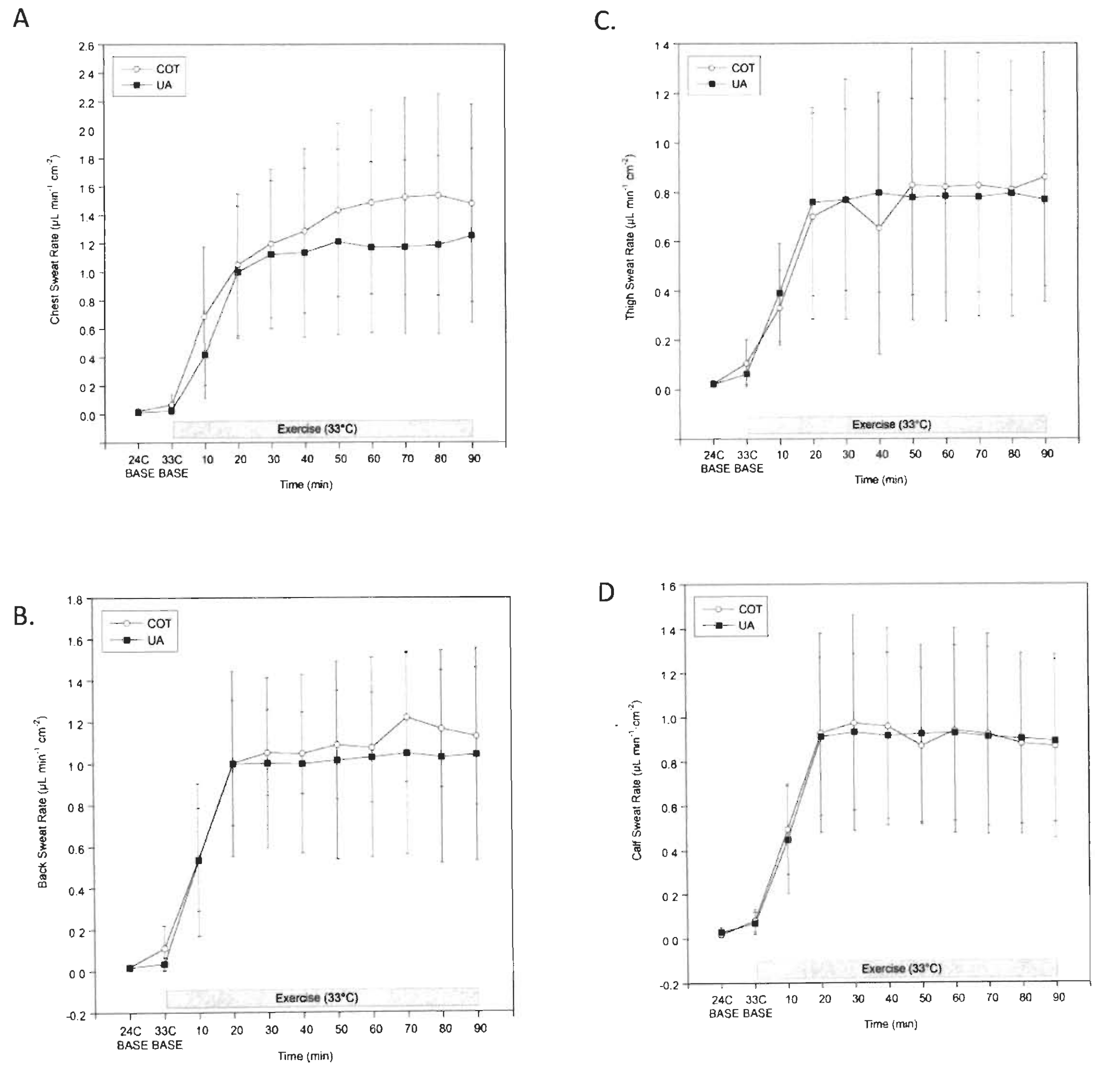

Figure 4. Chest (A), back (B), thigh (C), and calf (D) average sweat rate responses during heat stress tests (M $\pm$ SD) (Clothing x Time; chest: P = 0.169; back: P = 0.962; thigh: P = 0.403; calf: P = 0.944)

Total Body Sweat Loss and Rate

Overall, there was no significant difference between the clothing conditions with respect to total body sweat loss (COT: 1868.2 $\pm$ 794.82, UA: 1824.44 $\pm$ 805.87 mL ; P = 0.994).

Subject Variables

Thermal Sensation

Figure 5 displays the response in thermal sensation over time in the COT and UA clothing conditions. The main effect for clothing was not significant (COT: 6.0 $\pm$ 0.5, UA: 6.0 $\pm$ 0.5; $P = 0.871$). As expected, there was a significant main effect for time for thermal sensation ($P < 0.001$). The clothing-by-time interaction was not significant ($P = 0.529$).

Sweat Sensation

Figure 6 displays the response in sweat sensation over time in the COT and UA clothing conditions. The main effect for clothing was not significant (COT: 4.2 $\pm$ 0.2, UA: 4.2 $\pm$ 0.2; $P = 0.095$). As expected, there was a significant main effect for time for sweat sensation, ($P < 0.001$). The clothing-by-time interaction was significant ($P = 0.004$). Post-hoc testing revealed the sweat sensation was significantly lower during the UA condition at the 33°BASE time point.

Perceived Exertion

Figure 7 displays the response in sweat sensation over time in the COT and UA clothing conditions. The main effect for clothing was not significant (COT: 13.0 ± 2.0, UA: 12.00 ± 2.0; $P = 0.089$). As expected, there was a significant main effect for time for perceived exertion ($P < 0.001$). The clothing-by-time interaction was not significant ($P = 0.360$).

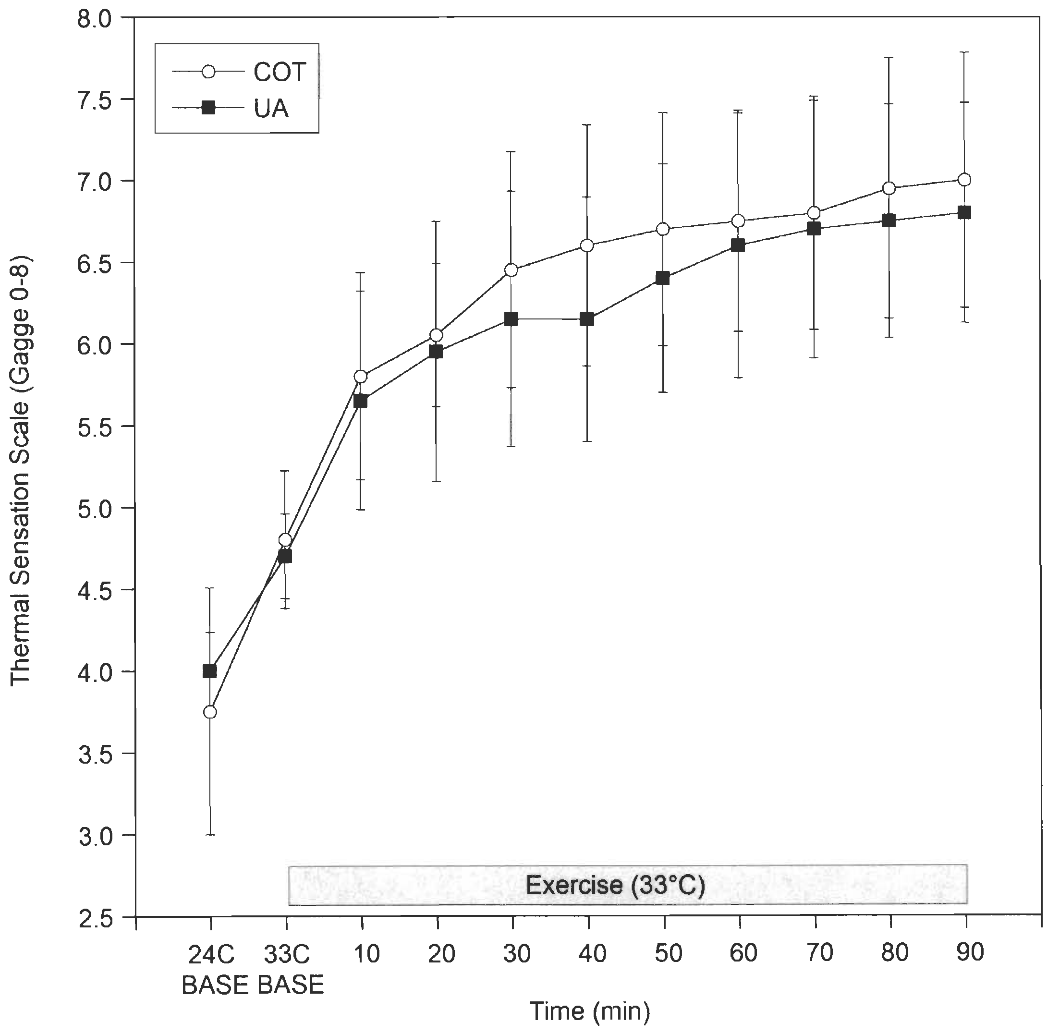

Figure 5. Thermal sensation response during heat stress tests (M ± SD) (Clothing x Time: P = 0.529)

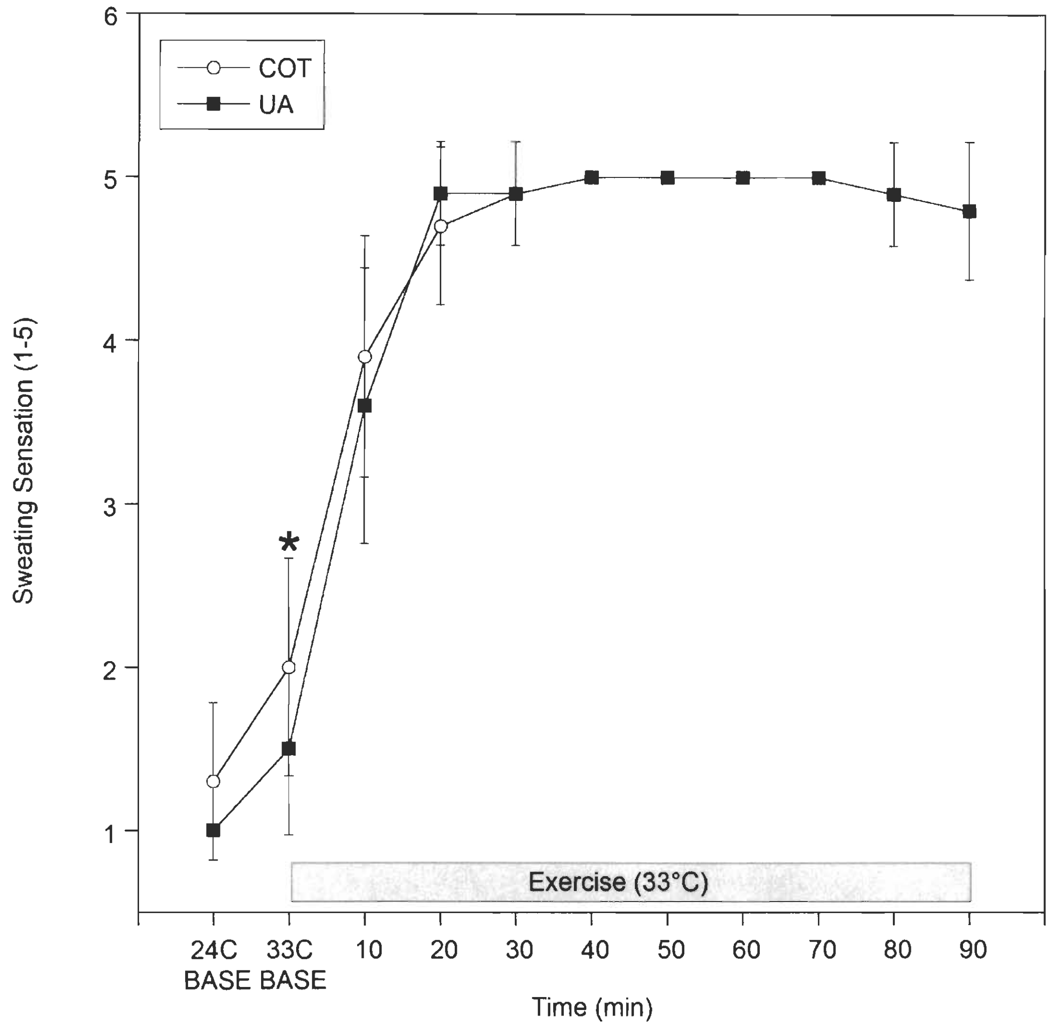

Figure 6. Sweat sensation response during heat stress tests (M $\pm$ SD)
(Clothing x Time: P = 0.004)
*** denotes a significant difference between the COT and UA conditions**

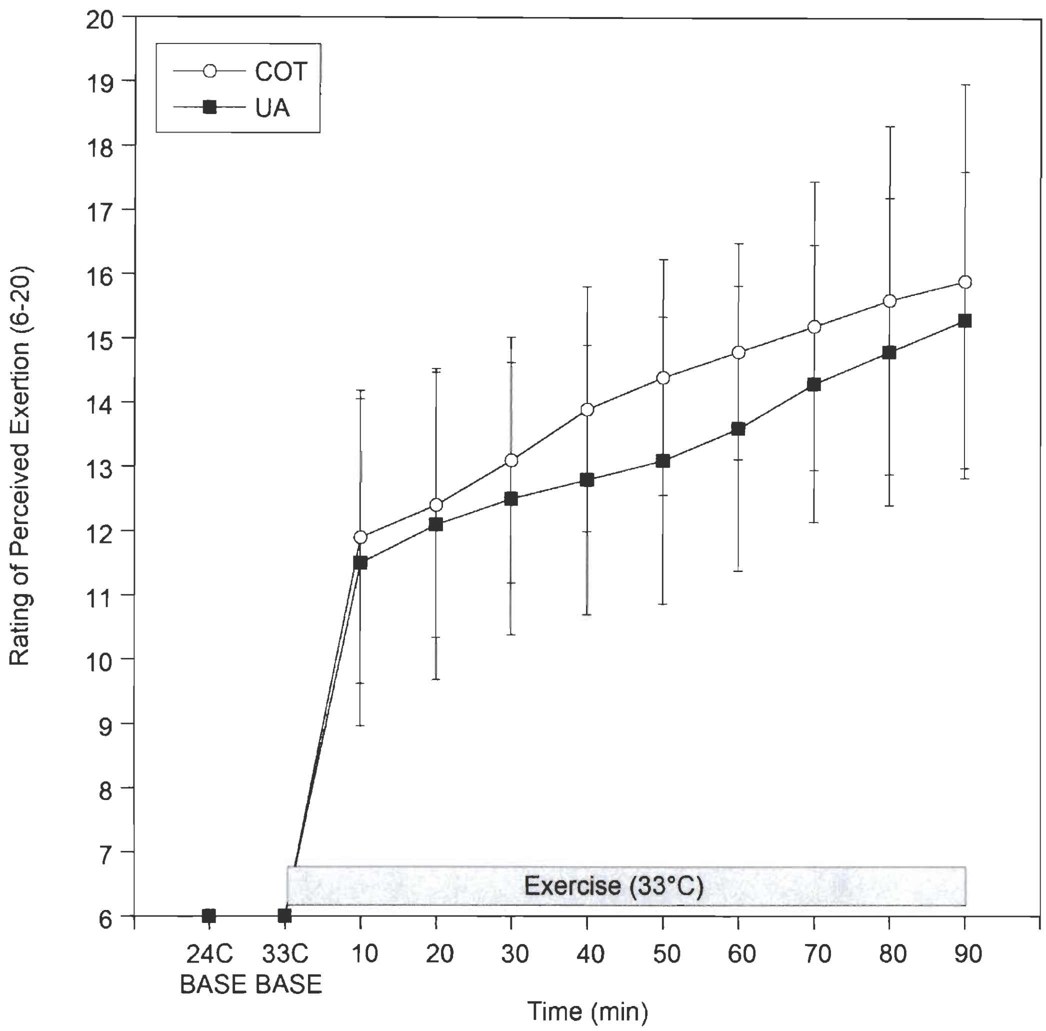

Figure 7. Perceived exertion response during heat stress tests (M ± SD) (Clothing x Time: P = 0.360)

Cardiovascular Variables

Heart Rate

Figure 8 displays the heart rate response in sweat sensation over time in the COT and UA clothing conditions. The main effect for clothing was not significant (COT: 136.0 ± 14.0, UA: 131.0 ± 13.0 b·min^{-1}; $P = 0.222$). As expected, there was a significant main effect for time for sweat sensation, ($P < 0.001$). The clothing-by-time interaction was not significant ($P = 0.439$).

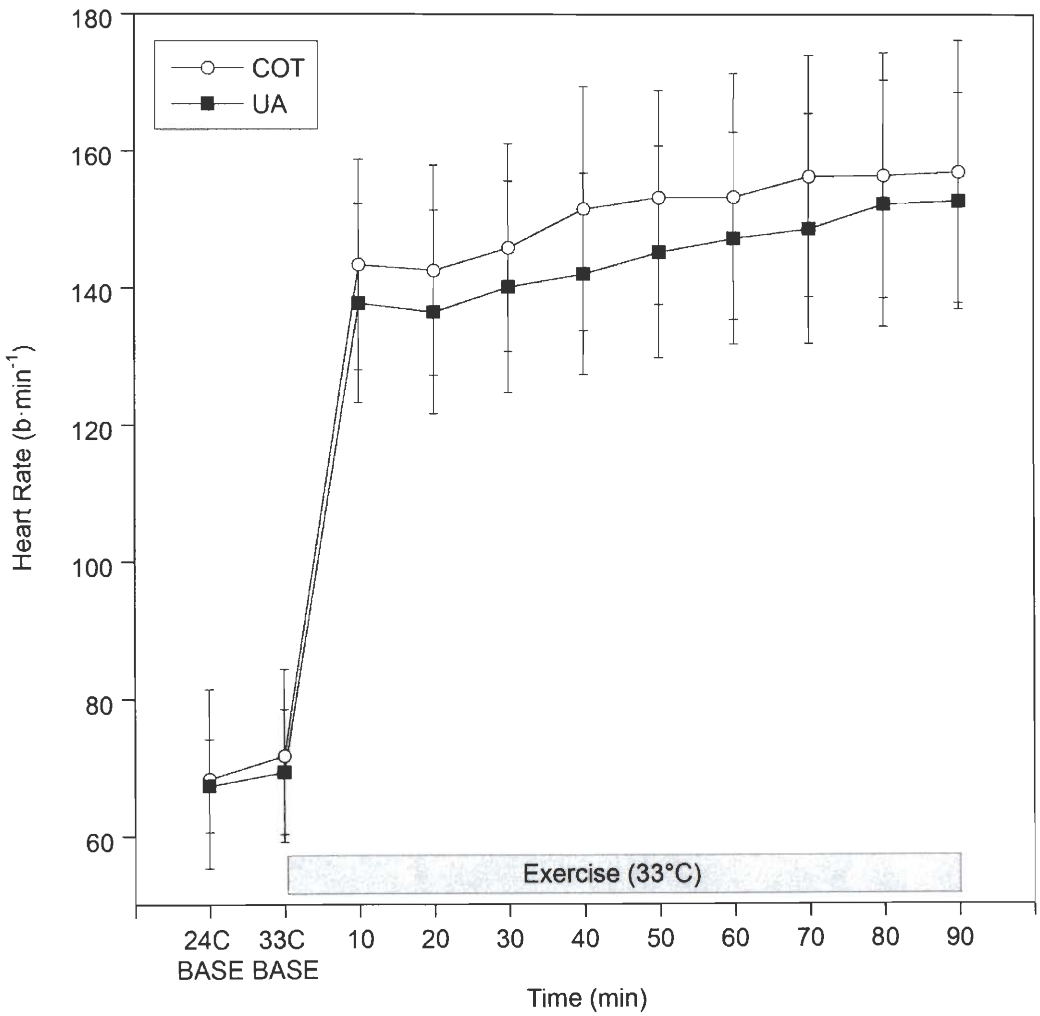

Figure 8. Heart rate response during heat stress tests (M $\pm$ SD) (Clothing x Time: P = 0.439)

CHAPTER IV

DISCUSSION

The purpose of this study is to investigate the effects that a form fitted, moisture-wicking fabric shirt, promoted to have improved evaporative and ventilation properties, has on the thermoregulatory, physiological and perceptual response during moderate intensity exercise in the heat for an extended duration of exercise of 90 minutes. Intensity of 50% VO_{2max} for a duration of 90 minutes in environmental conditions of 33° C/ 60% RH was selected in order to impose a heat load significant enough to stress the thermoregulatory system and stimulate conditions often imposed on an individual training aerobically in the summer. Also, the protocol was utilized to produce sufficient heat load where the moisture-wicking fabric shirt may prove beneficial in the maintenance of body temperature and performance without providing a metabolic load so severe that fatigue sets in too early, not stressing the thermoregulatory system adequately (13).

The present study showed no significant difference in T_{re} between the two conditions. Gavin et al. found no significant difference in T_{re} while examining polyester vs. cotton material during 30 minutes of exercise at 70% VO_{2max} in 30°C and 35% RH (13). Similarly, Brazaitis et al. found no significant difference in T_{re} while evaluation the effects that two kinds of long-sleeved t-shirts (94%

cotton/6% elastane; 93% polyester/7% elastane) has on the thermoregulatory response during exercise (8km/hr at 1° grade on a treadmill) in an environment (25°C and 60% RH) (3). The present study was designed to build on DeSousa's research (11), where the trend showed as the duration of the exercise progressed the UA condition maintained a lower T_{re} than the COT condition. Therefore, it is surprising to not have found statistical evidence of lower T_{re} in the present study for the UA condition as well. Zhang and Gong demonstrated that clothing with high air permeability resulted in significantly lower T_{re} during exercise in the heat with wind, but not without wind (28). Likewise, Brownlie et al. found that clothing with limited vapor permeability caused a significant increase in T_{re} during exercise in the heat with wind (4). In the present study wind was not utilized nor was it used in DeSousa's study, however, DeSousa found a significantly lower T_{re} during the last 15 minutes of exercise (11). It can be hypothesized that the use of wind would positively augment the thermoregulatory response in the UA condition. Clothing with increased air permeability will increase heat loss via convection as the wind carries away warm air surrounding the body (29). The present study tested three female subjects, unlike DeSousa's study (11), perhaps this was the reason no significant differences were found. Females wore a sports bra as well as the t-shirt, the double clothing layers could have masked any differences which would have been with the extended exercise duration.

When observing MT_{sk} during exercise, both the COT and UA conditions followed similar trends resulting in no significant difference. Cooler MT_{sk} in the UA condition would have been expected because of its high air permeability. Increases in clothing permeability and ventilation results in an increase of heat dissipation from the body to the environment (2). The ventilated back of the UA clothing may have allowed for an increase in heat loss and lower skin temperatures at the back, attenuating the MT_{sk}. Observing skin temperature during exercise in the heat with a thermocouple located on the back may provide additional information about the relationship between the ventilation properties of the UA clothing and skin temperature. However, the exercise duration may have placed such a strain on the body that the fabric type would have no effect on lowering skin temperature, essentially negating any moisture-wicking qualities in the UA shirt.

There was no significant difference in average sweat rate at the chest, back, thigh, and calf, suggesting that clothing of different fabric and characteristics may not affect sweat loss. This is in contrast to Ha et al., who found that fabrics with high air permeability and moisture regain resulted in lower sweat rates during intermittent exercise (30% VO_{2peak}) at 27°C (?). Similarily, Kwon et al. reported greater sweat rates in subjects wearing a long-sleeve 100% polyester shirt compared to a long-sleeved 100% cotton shirt during intermittent exercise at 40% VO_{2peak} in 30°C (22). The intermittent nature of the exercise combined with moisture regain properties of the fabric may be the reason for the differences in sweat rate observed in the previously mentioned studies and the current one. Brazaitis et al. found that during post-exercise recovery MT_{sk} tended to decline to lower than pre-exercise levels in subjects wearing cotton shirts compared to polyester ones (3), revealing the ability of clothing with high regain properties to cool the skin in a rested state. Furthermore, Ha et al. postulated that a lower sweat rate may be due to the combined effects of moisture regain and air permeability (17), however, due to the high RH and lack of wind, a lower sweat rate was not observed.

The cotton clothing retained a significantly greater amount of sweat than that of UA clothing. This exhibits the high sorption property of the cotton fabric and increased ability of the UA to promote greater evaporation of sweat. These findings agree with other studies utilizing similar protocols and environmental conditions. Gavin et al. Brazaitis et al., and DeSousa all demonstrated properties of less sweat sorption in the polyester condition with no impact on temperature regulation during exercise in the heat (13, 3, 11). The increased wicking ability of the UA condition did not subsequently alter body weight loss as no significant difference was observed between conditions, further reinforcing the notation that the reduced weight of the UA shirt was due to its greater evaporative characteristics.

Exercise in the heat at a constant intensity is associated with an increase in RPE as duration progresses (1). Both the COT and UA conditions followed similar trends steadily increasing with exercise duration. However, no significant difference in RPE or thermal comfort was attributed to the type of garment worn. It is important to note that the significant difference found in sweat sensation was only observed during the 33°CBASE portion of the test where the subject is seated and exercise is not involved. Gavin et al., also found no differences in thermal comfort and sweat sensation between exercise ensembles at any time point (12). Similarly, Brazaitis et al. and DeSousa found no significant differences in thermal sensation and sweat sensation during exercise between a cotton and polyester shirt (3, 11). Additionally, the above studies found significant differences in clothing weight pre- and post-exercise with the cotton shirt absorbing significantly more sweat than the polyester. There was a significant difference in the retention in the cotton fabric material than that of the polyester fabric material shirts ($P = 0.001$). It appears the sorption properties and type of garment fabric plays no role in the perception to thermal comfort, sweat sensation, and exertion during exercise in the heat.

Heart rate in both the UA and COT conditions quickly increased within the first five minutes of exercise before gradually leveling off at steady state with gradual increases until the cessation of exercise. Overall, there was no significant difference between clothing conditions, possibly due to the equivalent amount of subject fluid loss between conditions resulting in a uniform cardiovascular stress. These findings are similar to Gavin et al., and DeSousa, who both found no significant difference in HR between cotton and polyester garments during exercise in the heat (12,13,11). Conversely, Ha et al. found that subjects wearing cotton garments had higher HR than those wearing polyester garments during intermittent exercise (30% VO_{2peak}) at 27°C, citing reduced thermal insulation sue to absorption of moisture by the cotton fabric as the cause for accelerated heat loss (17). However, the increase in moisture absorption because of high regain properties in the cotton garment would allow for delayed evaporative cooling during the rest phase not observed in the Gavin et al. (13) and DeSousa's study (11). The synthetic polyester fabric appears to wick moisture away more efficiently during prolonged exercise, where the cotton fabric becomes saturated, decreasing the ability to evaporate sweat and cool the body while exercising.

The current study tested both male and female subjects, diverging from the previous research performed by Gavin et al., Brazaitis et al., and DeSousa (11,12,13,3). Gender differences were not calculated in the statistical analysis due to the unequal grouping. Perhaps further research would be warranted to investigate the moisture-wicking properties of the sports bra to see if the greater surface area would significantly affect the thermoregulatory, physiological, and perceptual responses during moderate exercise.

In conclusion, there was no significant difference with respect to rectal temperature observed between the form fitting, moisture-wicking polyester fabric shirts versus the cotton shirt. Although the polyester shirt is promoted to have moisture-wicking properties and improve thermoregulation during exercise, researchers saw no significant difference to distinguish UA to positively impacts thermoregulation, physiological, and perceptual responses during prolonged exercise in the heat. Perhaps some additional research is warranted to investigate whether the polyester material is most effective in windy environments which would aid the evaporation of sweat.

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Appendix A
Human Subjects Institutional Review Board Approval Letter

WESTERN MICHIGAN UNIVERSITY

Human Subjects Institutional Review Board

Date: December 4, 2012

To: Christopher Cheatham, Principal Investigator
Kimberly Wigboldy, Student Investigator for dissertation

From: Amy Naugle, Ph.D., Chair Amy Naugle

Re: HSIRB Project Number 12-10-26

This letter will serve as confirmation that your research project titled "The Effect of a Moisture-Wicking Fabric Shirt on the Physiological Responses during Acute Exercise in the Heat" has been **approved** under the **full** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may **only** be conducted exactly in the form it was approved. You must seek specific board approval for any changes in this project (e.g., ***you must request a post approval change to enroll subjects beyond the number stated in your application under "Number of subjects you want to complete the study***)." Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: October 17, 2013

Walwood Hall, Kalamazoo, MI 49008-5456
PHONE: (269) 387-8293 FAX: (269) 387-8276

Appendix B
Human Subjects Institutional Review Board Informed Consent

Western Michigan University
Department of Health, Physical Education and Recreation

Principal Investigator: Christopher C. Cheatham, Ph.D.

Student Investigator: Kimberly A. Wigboldy, B.A.

Title of Study: The Effects of a Moisture-Wicking Fabric Shirt on the Physiological Responses during Acute Exercise in the Heat

You have been invited to participate in a research project titled "The Effects of a Moisture-Wicking Fabric Shirt on the Physiological Responses during Acute Exercise in the Heat." This project will serve as Kimberly Wigboldy's thesis project for the requirements of the Master of Science in Exercise and Sports Medicine (Exercise Physiology Concentration) degree. This consent document will explain the purpose of this research project and will go over all of the time commitments, the procedures used in the study, and the risks and benefits of participating in this research project. Please read this consent form carefully and completely and please ask any questions if you need more clarification.

What are we trying to find out in this study?

When we exercise our working muscles produce heat, which causes an increase in body temperature. In an attempt to remove excess heat there is an increase in skin blood flow, followed by sweating. When exercising in a hot and humid environment the increase in heat exposure places greater strain on the body's ability to lose heat and maintain body temperature. Thus, the body has to increase its' production of sweat. The use of clothing provides a layer of insulation and a barrier between the skin and the environment, so that heat cannot easily escape from the body. Traditional fabrics like cotton and wool trap heat and absorb sweat, which may lead to discomfort and decreases in heat loss. Synthetic fabrics, on the other hand, are designed to remove sweat from the body and have been suggested to improve heat loss, possibly leading to increased comfort and less of an increase in body temperature during exercise. Therefore, the purpose of this study is to assess the effects of wearing a synthetic moisture-wicking fabric t-shirt on body temperature, sweat rate and heart rate during 90 minutes of cycling at a moderate intensity in the heat.

Who can participate in this study?

In order to be eligible to participate, you must be between the ages of 18 and 35 years and meet the following criteria:

- You must be healthy, free of disease and free of medication use which may affect the cardiovascular or metabolic responses during exercise;
- You must be free of any orthopedic injuries or conditions that would make exercise difficult;
- You must be classified as "Low-Risk" for cardiovascular disease based on the American College of Sports Medicine's Risk Stratification guidelines;
- You must be recreationally active;
- You must not be classified as being obese.

If you agree to participate and sign this consent form, these criteria will be determined by having you complete several health history questionnaire forms. The determination of whether or not you are classified as being obese will be determined from measurements of your height and weight.

Where will this study take place?

This study will take place in the Human Performance Research Laboratory which is located on the first floor of the Student Recreation Center at Western Michigan University.

What is the time commitment for participating in this study?

If you choose to be part of this study, you will be asked to come to the laboratory on three separate days. The first day will take approximately one hour. The second and third days will take approximately 3 hours each day.

Thus, the total time commitment is approximately seven hours.

Overall, we would like to have you finish the study within five to six weeks of starting it.

What will you be asked to do if you choose to participate in this study?

We will ask you to come to our laboratory three times. The first visit is the "Orientation / Graded Exercise Test" visit and the second and third visits are for the "Heat Stress

Tests". During one of the heat stress tests you will wear a traditional cotton t-shirt. During the other heat stress test you will a moisture-wicking fabric t-shirt (UnderArmour). Before each visit to the laboratory, we will ask you to not drink any alcohol or caffeine the day before and day of your visits to the laboratory. We will also ask that you not exercise the day before and the day of your visits to the laboratory. Lastly, we will ask you to wear a t-shirt, shorts, and athletic shoes to each visit to the laboratory.

Orientation / Graded Exercise Test Visit

If you choose to participate in the study and sign the informed consent form, we will have you complete two health history questionnaires and measure your height and weight. We will use this information to determine if you are eligible to continue participating in the study.

We will then measure your percent body fat using a skinfold caliper. We will measure the thickness of your skin and the layer of fat underneath it at seven different places on your body. We will then enter these numbers into a math equation to determine your percentage body fat.

We will then have you perform a maximal exercise test on a stationary bike to determine your fitness level (how much oxygen your body uses). We will strap a heart rate monitor around your chest. We will also explain how to use the Borg Ratings of Perceived Exertion (RPE) Scale. This is a scale with numbers and words describing how hard the exercise is. To use the scale, you simply point to a number. We will then hook you up to the "Metabolic Measurement Cart" so that we can measure how much oxygen your body uses during exercise and how much carbon dioxide your body produces. To do this, you will breathe through a clean, sanitized mouthpiece (similar to a snorkel mouthpiece) and you will wear a pair of noseclips so that you can only breathe through your mouth. The air you blow out during exercise goes into the "Metabolic Measurement Cart" and the amount of oxygen and carbon dioxide is measured.

We will then begin the exercise test. You will pedal on the stationary bike for two minutes at a very easy intensity. We will then make the exercise more difficult every one minute by increasing the resistance that you have to pedal against. When the resistance increases to a level that you can't pedal against, the exercise test will be over. This is called volitional fatigue and is the point during exercise when you feel like you can exercise no longer. In other words, the exercise is just too hard to continue. This feeling might occur due to leg fatigue, overall fatigue, hyperventilation (rapid breathing), or other factors relating to maximal exercise. This exercise test usually takes between 8 and

15 minutes. After the test is over we will have you pedal at a very low exercise intensity so that you can cool-down. During this test we will record your heart rate every 30 seconds and ask that you indicate how hard the exercise feels every 1-2 minutes.

Heat Stress Test Visits

The second and third visits to the laboratory are for the heat stress tests. The tests will be the same on the second and third visits except that one time you will do the test while wearing a traditional cotton t-shirt, while for the other visit you will wear a moisture-wicking fabric t-shirt.

When you get to the laboratory for the heat stress tests, we will again measure your body weight. You will then be given instructions on how to insert the rectal temperature probe and you will then insert the probe yourself in a private restroom. We will then attach some small wires and tubes to your skin so that we can measure the temperature of your skin and how much sweat your skin is producing. We will also hook you up to the metabolic measurement cart and the heart rate monitor so that we can measure how much oxygen your body is using and your heart rate. Once you are hooked up to all the instruments, we will ask that you sit in a comfortable chair in our environmental chamber for 20 minutes. The temperature in the chamber will be 74°F. After that we will raise the temperature in the room to 91°F and you will sit for 30 minutes. After this 30 minutes of seated-rest, you will exercise in the 91°F air on a cycle ergometer at a moderate intensity for 90 minutes. During the first heat stress test, you can drink as much water as you would like. At the end of the first test, we will measure how much water you drank and we will ask you to drink this same amount for the second heat stress test. After that, the heat stress test is finished and we will disconnect you from all the equipment and have you rest for a few minutes in cooler air. After you have cooled down for a few minutes, we will again measure your body weight.

What information is being measured during the study?

This section will describe the measurements that we are going to take during your participation in the study.

Health Status/Medical History: We will be collecting information about your health status from the health history questionnaires.

Height, Weight, Percent Body Fat: We will be measuring your height, your weight, and the percentage of your body weight that is fat.

Core Temperature: Core temperature is the temperature inside your body. Core temperature will be measured using a rectal temperature probe. We will measure core temperature throughout the heat stress tests (second and third visits to the laboratory). To measure core temperature using a rectal temperature probe, you will be given a temperature probe with a small piece of tape on it. In a private restroom, you will be asked to insert the probe into your rectum approximately 5-6 inches (up to the piece of tape). The other end of the probe will come out the top of your shorts in the back. Before you insert the probe, we will ask you to place some lubricating jelly on the tip of the probe so that it goes in more comfortably.

Metabolic Rate / Oxygen Consumption: During each visit to the laboratory, we will measure how much oxygen your body uses and how much carbon dioxide your body produces using a metabolic measurement system. To do this, you will breathe through a clean, sanitized mouthpiece (similar to a snorkel mouthpiece) and you will wear a pair of noseclips so that you can only breathe through your mouth. The air you blow out during exercise goes into the "Metabolic Measurement Cart" and the amount of oxygen and carbon dioxide in the air you breathe out is measured."

Heart Rate: Your heart rate, or how many times your heart beats every minute will be measured throughout each visit to the laboratory. We will measure heart rate by strapping a heart rate monitor around your chest.

Skin Temperature: During the heat stress tests, we will measure the temperature of your skin at four places on your body. To do this, we will attach small wires to the top of your skin using tape and/or a small amount of a glue that is designed to be used on the skin.

Sweat Rate: During the heat stress tests, we will measure how much sweat your body is making at several places on your body. To do this, we will attach small plastic disks to the top of your skin using tape and/or a small amount of glue that is designed to be used on the skin.

Thermal and Sweating Sensation: Throughout the second, third, and fourth visits to the laboratory, we will ask you how you feel temperature-wise and how you perceive your level of sweating to be by asking you to point to a number on a chart.

What are the risks of participating in this study and how will these risks be minimized?

Measuring Height and Weight: There are no known risks associated with the measurement of height and body weight.

Assessing Percent Body Fat via Skinfold Thickness: You may experience some slight discomfort due to the pulling of the skin and the application of the skinfold calipers. However, this discomfort, if experienced, is minor and is only when we are doing the measurement. We will attempt to minimize the possibility of any discomfort by following proper standardized procedures. Also, the investigators are experienced at performing skinfold measurements.

Measurement of Heart Rate, Thermal Sensation, and Sweating Sensation: There are no known risks associated with the measurement of heart rate using a telemetry heart rate monitor or measuring your thermal or sweating sensation by having you point to a chart.

Exposure to Heat: Rest and/or exercise in the heat can cause light-headedness, a feeling of tiredness, an increase in your body temperature, and an overall feeling of discomfort. During the experiment, we will be constantly monitoring your body temperature. If your body temperature increases past a certain level, we will stop the experiment and move you to a cooler temperature. The temperature that we stop the experiment at is below any dangerous level to your body.

Maximal Exercise: Intense, maximal exercise can cause feelings of tiredness, weakness, dizziness, and nausea. When exercising, there is always a risk for musculoskeletal injuries (muscle strains, pulls, cramping). Lastly, there is always a risk for a cardiac event (i.e. chest pain, heart attack). However, this risk is extremely low. The American College of Sports Medicine states that the risk of such an event in a younger healthy population is only 0.1 incidents out of every 10,000 maximal exercise tests. In order to minimize these risks, we will confirm that you are classified as "low-risk" using the health history questionnaires. Also, we will have you stretch before the exercise to reduce the risk for musculoskeletal injuries. Lastly, an investigator will always be next to the cycle ergometer and will be monitoring your heart rate and how you feel. The investigators all have experience in performing this test and are also first-aid and CPR certified.

Moderate-Intensity Exercise: Exercise may cause the feeling of fatigue, light-headedness, and an overall feeling of discomfort. There is also a risk for muscle soreness and musculoskeletal injuries (muscle pulls, strains). The exercise may be stressful but is generally easily tolerated by individuals and is not dangerous for healthy individuals. The investigators are trained in performing exercise tests and are familiar with emergency procedures. Also, we will be monitoring your heart rate and body temperature to make sure that your body is tolerating the exercise.

Core Temperature: The measurement of core temperature using a rectal probe may cause some slight discomfort. The insertion of the probe may cause some slight discomfort but this will be minimized by using a lubricating jelly on the tip of the probe. The slight discomfort may continue while the temperature probe is in place.

Skin Temperature and Skin Sweat Rate: There are no known risks associated with measuring skin temperature by taping small wires to the surface of your skin or measuring sweat rate by attaching small plastic disks to your skin.

Other Risk Considerations: Participation in this study requires approximately six hours of your time and therefore may be an inconvenience to you.

Other Protection Considerations: The principal investigator has extensive experience performing the measurements outlined in this application. The principal investigator was trained during his doctoral work at Kent State University and during his post-doctoral work at the John B. Pierce Laboratory at the Yale University School of Medicine. The student investigator has been trained in all of the laboratory exercises and has extensive experience in exercise testing.

As in all research, there may be unforeseen risks to the participant. If an accidental injury occurs, appropriate emergency measures will be taken; however, no compensation or additional treatment will be made available to you except as otherwise stated in this consent form.

What are the benefits of participating in this study?

You will learn about your fitness level and percent body fat and how your fitness level and percent body fat compare to individuals of your same age. Other than that, there may be no direct benefit to your participation in this study.

Are there any costs associated with participating in this study?

There are no monetary costs to you for participating in this study.

Is there any compensation for participating in this study?

There is no monetary compensation for participating in this study. Upon completion of your participation in the study, you will get to keep the moisture-wicking fabric t-shirt that we used in the study.

Who will have access to the information collected during this study?

Only the investigators will have access to your data. To maintain confidentiality, a personalized identification number will be assigned to you and be used to record data collected throughout the study. Your name will never be associated with your data. If the results of the study are published in a journal or presented at a conference, no names or other identifying information will ever be used.

The original data will be retained in a locked cabinet for a minimum of three years after the completion of the study in the department of Health, Physical Education, and Recreation at Western Michigan University.

What if you want to stop participating in this study?

You can choose to stop participating in the study at any time for any reason. You will not suffer any prejudice or penalty by your decision to stop your participation. You will experience NO consequences either academically or personally if you choose to withdraw from this study.

The investigator can also decide to stop your participation in the study without your consent.

Should you have any questions prior to or during the study, you can contact the primary investigator Christopher C. Cheatham at 269-387-2542 or chris.cheatham@wmich.edu. You may also contact the Chair, Human Subjects Institutional Review Board at 269-387-8293 or the Vice President for Research at 269-387-8298 if questions arise during the course of the study.

This consent document has been approved for use for one year by the Human Subjects Institutional Review Board (HSIRB) as indicated by the stamped date and signature of the board chair in the upper right corner. Do not participate in this study if the stamped date is older than one year.

I have read this informed consent document. The risks and benefits have been explained to me. I agree to take part in this study.

____

Please Print Your Name

____

Participant's signature Date

Appendix C
Health History Questionnaire

Health/Medical History Questionnaire

Thank you for volunteering to participate in research at the Human Performance Research Laboratory of Western Michigan University. It is important that we have an accurate assessment of your present health status to assure that you have no medical conditions or previous injuries that may make participation in this study especially dangerous for you. *Please complete the health history questionnaire as accurately as you can.*

THIS MEDICAL HISTORY IS CONFIDENTIAL AND WILL BE SEEN ONLY BY THE INVESTIGATORS.

Name:____Date:_______

Date of Birth:_____________ Present Age:_____yrs

Ethnic Group:

- ☐ White
- ☐ Black
- ☐ Hispanic
- ☐ Asian
- ☐ Pacific Islands
- ☐ American Indian
- ☐ Other________________

HOSPITALIZATIONS AND SURGERIES

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

Name:________________________________ Medical History, page 2

YEAR	OPERATIONS OR ILLNESS

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

If yes, please explain:____

____

____

____

MEDICATIONS

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

☐ Check this box if you have not taken any medications.

MEDICATION	REASON YOU ARE PRESENTLY TAKING THIS

Name:____________________________________ Medical History, page 3

PROBLEMS AND SYMPTOMS

Please place an “X” in the box next to any of the following problems or symptoms that you have had:

General

☐ Mononucleosis If yes, when __________________

☐ Recent weight loss while not on a diet

☐ Recent weight gain

☐ Thyroid disease

☐ Fever, chills, night sweats

☐ Diabetes

☐ Arthritis

☐ Heat exhaustion or heat stroke

☐ Abnormal chest x-ray

☐ Pain in chest (persistent and/or exercise related)

☐ Heart attack

☐ Coronary artery disease

☐ High blood pressure

☐ Rheumatic fever

☐ Peripheral vascular disease

☐ Blood clots, inflammation of the veins (phlebitis)

☐ Asthma, emphysema, bronchitis

☐ Shortness of breath ☐At rest ☐ On mild exertion

Name:__________________________________ Medical History, page 4

- ☐ Discomfort in chest on exertions
- ☐ Palpitation of the heart; skipped or extra beats
- ☐ Heart murmur, click
- ☐ Other heart trouble Please explain________________________________
- ☐ Lightheadedness or fainting
- ☐ Pain in legs when walking
- ☐ Swelling of the ankles
- ☐ Need to sleep in elevated position with several pillows
- ☐ High cholesterol If yes, what was the last measured value?____________

Nervous System

- ☐ Frequent or severe headaches
- ☐ Stroke
- ☐ Attacks of staggering, loss of balance, dizziness
- ☐ Persistent or recurrent numbness or tingling hands or feet
- ☐ Episode of difficulty in talking

Musculoskeletal

- ☐ Recent soft tissue injury (deep bruises, charley horse, muscle strain)
- ☐ Recent or chronic joint sprain If yes, which joint(s)?__________________
- ☐ Unstable joint If yes, which joint(s)?__________________
- ☐ Limited range of motion If yes, which joint(s)?__________________
- ☐ Rheumatoid arthritis
- ☐ Back or neck pain, sacroiliac pain

Name:________________________________ Medical History, page 5

☐ Pain radiating from back down limbs

Please give details for any items checked (when, severity, treatment):

____

____

____

Other

Have you ever passed out during or after exertion? ☐ Yes ☐ No

Do you have a family history of coronary artery disease? ☐ Yes ☐ No

If yes, who? ____

Do you use (complete the information if your answer is yes):

Tobacco	☐ Yes	☐ No	Cigarettes	____	per day____
			Smokeless	____	per day____
			Pipe	____	per day____
			Cigars	____	per day____

ALLERGIES

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

☐ **Check this box if you have no allergies**

1.____

2.____

Name:________________________________ Medical History, page 6

3.____

4.____

I, ____________________, have completed this medical/health history questionnaire honestly and completely as possible.

______________________________________ ______________

Participant Signature

Date

Reviewed and approved for participation:

______________________________________ ______________

Principal or Student Investigator Date

TABLE 2. AHA/ACSM Health/Fitness Facility Preparticipation 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	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.
Symptoms _____ You experience chest discomfort with exertion. _____ You experience unreasonable breathlessness. _____ You experience dizziness, fainting, blackouts. _____ You take heart medications.	Other health issues: _____ You have musculoskeletal problems. _____ You have concerns about the safety of exercise. _____ You take prescription medication(s). _____ You are pregnant.
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 $>$140/90. _____ You don't know your blood pressure. _____ You take blood pressure medication. _____ Your blood cholesterol level is $>$240 mg/dL. _____ You don't know your cholesterol level. _____ You have a close blood relative who had a heart attack before age 55 (father or brother) or age 65 (mother or sister). _____ You are diabetic or take medicine to control your blood sugar. _____ You are physically inactive (ie, you get $<$30 minutes of physical activity on at least 3 days per week). _____ You are $>$20 pounds overweight.	If you marked 2 or more of the statements in this section, consult your healthcare provider before engaging in exercise. You might benefit by using a facility with a professionally qualified exercise staff to guide your exercise program.
_____ None of the above is true.	You should be able to exercise safely without consulting your healthcare provider in almost any facility that meets your exercise program needs.

AHA/ACSM indicates American Heart Association/American College of Sports Medicine.

Appendix D
Borg Scale of Perceived Exertion

BORG SCALE OF PERCEIVED EXERTION

6	
7	Very, Very Light
8	
9	Very Light
10	
11	Fairly Light
12	
13	Somewhat Hard
14	
15	Hard
16	
17	Very Hard
18	
19	Very, Very Hard
20	

Appendix E
Gagge Thermal Sensation Scale

Gagge Thermal Sensation Scale

0.0	Unbearably Cold
0.5	
1.0	Very Cold
1.5	
2.0	Cold
2.5	
3.0	Cool
3.5	
4.0	Neutral (Comfortable)
4.5	
5.0	Warm
5.5	
6.0	Hot
6.5	
7.0	Very Hot
7.5	
8.0	Unbearably Hot

Gagge, A.P., A.J. Stolwijk, and J.D. Hardy. Comfort and thermal sensations associated with physiological responses at various ambient temperatures. *Environmental Research.* 1: 1-20, 1967.

Appendix F
Sweat Sensation Scale

SWEAT SENSATION SCALE

1	Dry
2	Clammy
3	Moist
4	Wet
5	Dripping Wet