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Physiological and Perceived Psychological Responses of Collegiate Football Athletes to Ventilated Shoulder Pads During a Scrimmage

Kathryn Claire Tice

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PHYSIOLOGICAL AND PERCEIVED PSYCHOLOGICAL RESPONSES OF
COLLEGIATE FOOTBALL ATHLETES TO VENTILATED SHOULDER PADS
DURING A SCRIMMAGE

ABSTRACT

by

Kathryn Claire Tice

(Under the Direction of James McMillan)

PURPOSE: The purpose of this study was to assess the effect of cold air ventilated shoulder pads on core temperature and perceived exertion in football athletes during a scrimmage.

METHODS: Eight football athletes were randomly divided into two groups, one receiving cold air ventilation (v) and the other receiving no treatment (nv). Ratings of perceived exertion were taken and core temperatures were taken using a radio frequency device and swallowed CorTemp pills.

RESULTS: Data were analyzed using paired and independent sample T-tests. There were no significant differences in core temperature or RPE between the ventilated and non-ventilated groups. No significant difference was found among ventilated subjects pre and post treatment.

CONCLUSIONS: Although the RPE values were not significantly different between groups, there was a trend found among the data with post cooling RPE values, suggesting a psychological benefit for those receiving the cold-air treatment.

INDEX WORDS: Thermoregulation, Football, Core body temperature, Hyperthermia

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Kathryn Claire Tice

B.S. Bridgewater College, 2005

A Thesis Submitted to the Graduate Faculty of Georgia Southern University in Partial
Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

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2008

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DEDICATION

I dedicate this work to the glory of God, in honor of
my family and in loving memory of my father
without whom none of this would be possible.

ACKNOWLEDGMENT

In appreciation of my advisor, Dr McMillan and committee members,
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INTRODUCTION

Physical activity in hot and humid environments is known to be not only uncomfortable, but also stressful to the body both physiologically and psychologically. Heat-related illness is the third leading cause of death in high school athletes. Non fatal illnesses due to the dangerous combination of heat, humidity and physical activity continue to be underreported and under prepared for (Coris et al 2004). In addition, a rise in the ambient temperature in combination with humidity may be detrimental to athletic performance due to feelings of increased temperature and onset of fatigue.

Athletes participating in the sport of American football every summer are exposed to hot and humid temperatures during multiple practices each day in preparation for the competitive season. The core body temperatures that these athletes are reaching can be potentially dangerous if not fatal. Cooper et al (2006) reported the highest incidence of exertional heat illness among southeast universities occurs during the month of August. Therefore, athletic support staff should be informed of and trained on monitoring their athletes core temperatures, as well as the usefulness of equipment and treatments available, such as ventilated shoulder pads, designed to maintain a safe core temperature. Yeargen et al (2006) reported 141 cases of heat illness in football athletes from 2003-2005. These included heat stroke (1 case), heat exhaustion (121 cases) and heat cramps (19 cases). In addition, 8,000 deaths from heat illness and relating conditions during 1980-90's have been reported in both exercising and non exercising populations (Cooper et al 2006). It is safe to assume many more individuals and athletes have experienced the performance limiting, and potentially health threatening effects of heat stress and exhaustion.

PHYSIOLOGICAL CHANGES IN RESPONSE TO HEAT

A rise in core temperature and subsequent muscular temperature has been shown to produce higher glycogen utilization and decreased blood flow to active muscles with ensuing decreases in muscular contraction efficacy. Additional responses include increases in heart rate and perceived exertion, lactate production, fluid loss and dehydration. Decreased blood flow to active muscles due to peripheral shunting and electrolyte imbalance from sweat evaporation and fluid loss can also occur through hyperthermia (Drust et al 2005). Muscular changes in response to increased temperature include increases in cross bridge cycling rate, energy turnover, glycolytic rate and phosphocreatine hydrolysis. Cross bridge cycling rates benefit power/velocity increases and power output amplification.

Increasing core temperature leads to increased blood flow to the peripheral vessels for heat exchange with the environment. Through this, the amount of blood returning to the heart for recirculation decreases, as does overall blood volume due to sweating and fluid loss (Fortney et al 2008). An estimated 70% of metabolic heat produced through exercise is transferred from the core to the periphery for heat exchange into the environment (Chin Leong Lim et al 2008). The remaining heat produced is then used for mechanical work by the body. Reductions in blood volume and subsequent blood pressure decreases can be harmful to an exercising individual. Particularly during sub-maximal exercise, acclimatization to both the weather and the physical activity can allow blood flow to become more regulated and the body more efficient sweating for heat exchange (Fortney et al 2008).

PSYCHOLOGICAL CHANGES

In addition to physiological changes, psychological changes are seen with hyperthermia. Psychologically, increases in core body temperature can speed up the onset of central nervous system fatigue resulting in changes in mood, arousal level and motivation levels (Low et al 2005). Central nervous system fatigue and subsequent performance decreases due to excessively high body temperatures are said to occur when the body reaches around 39°C (102°F) through strenuous exercise and environmental conditions (Linnane et al 2004).

The body's ability to regulate the effects of ambient air temperature, humidity, clothing, and skin surface area (for sweat evaporation) during exercise also impacts the body's thermoregulatory response and ensuing effects (Pascoe et al 1994). When the body is efficient in regulating its temperature in response to heat, humidity, and other external factors the chance that problems will arise due to hyperthermia, dehydration, and other conditions decreases. Thermoregulation in the body is dependent on both metabolic heat production through exercise that increases core body temperature and the environmental conditions in which the exercise is occurring, which influences mainly skin temperature (Brotherhood et al 2008). The ability to control the core body temperature depends on the body's ability to sweat, removing heat through the blood to the peripheral blood vessels and out through sweat evaporation (Fortney et al 1985). The affect of the environment on the body's ability to evaporate sweat dictates the exchange of heat from body to air and increases or decreases the risk for heat related illness (Brotherhood et al 2008).

THERMOREGULATION

A few thermoregulation and hyperthermia studies have focused on football players; however these studies took place indoors in a controlled environment using drills or exercises simulating a football game (Wailgum and Paolone 1984, and Kulka and Kenney 2002). The current study focused solely on collegiate football during a simulated game with full pads in the heat and humidity of August.

This study attempted to support data obtained by Hitchcock and Stafford et al (2007). Their analysis of the metabolic cost of football, particularly in the heat with the use of equipment in simulated practice situations, though effective, was not all that practical due to the use of simulated drills and practices rather than actual play on the field. Hitchcock and Stafford et al (2007) found that the sharpest increase in metabolic cost and potentially core body temperature was shown when shoulder pads were worn by athletes who had not been acclimated to the environmental temperatures incurred during the simulated practice.

The first hypothesis was that athletes who receive cool air shoulder pad ventilation will have a lesser increase in core body temperature than the control, non-ventilated group. The second hypothesis was that the perceived exertion performed during the scrimmage by ventilated athletes will be lower than in the non-ventilated control group. With updated regulations and continuing research the amount of deaths and serious illness has decreased; however, more research is necessary to determine what can be done to improve safety procedures and devices utilized during exercise in the heat.

The purpose of this study, therefore, was to examine the efficacy of ventilated shoulder pad on core body temperature of Division I football players during summer training in the south east United States.

CHAPTER I

REVIEW OF LITERATURE

Previous work has determined that football players, especially those with large body mass, experience an increase in core body temperature because of increased energy demand, particularly during heat (Godek et al 2006). In addition, the amount of time it takes to become acclimated to heat and the ability to dissipate heat is hampered by greater muscle mass (Godek et al 2006). Athletes today are heavier than those who played in the past and those who participated in the few previous studies (Hitchcock et al 2007). Due to the rising trend in body mass and associated risk for heat related illness, a cooling system may be necessary for heavier athletes (134kg+) particularly during extreme environmental temperatures during training and competition (Hitchcock et al 2007). Pre-cooling, cooling devices, face cooling and other treatments have been studied in athletics in a variety of temperatures.

Although, heat stress studies examining cycling sprint performances are not as applicable to the sport of American football, examination of thermoregulation treatments have been done and assist in developing an overall picture for hyperthermia illnesses. Football, unlike cycling, involves discontinuous exercise or plays separated by periods of rest. Drust et al (2005) showed that during an intermittent cycling sprint performance of between 40-60 minutes, the cyclist's muscle lactate increased. In addition, electrolytes such as plasma potassium and catecholamine levels increased in response to exercise. Hormones such as epinephrine, one type of catecholamine, are released in response to stress, to prepare the body for physical activity, or increasing physical demands. Increasing potassium levels are of course, essential to muscle contractility as well as

neuron function, while amplified lactate arises from the increased energy demands from sprint cycling and the hydrolyzed ATP.

The authors reported, however that performance during repeated high intensity cycling was hindered by increases in core body temperatures (as well as muscle temperature). While athlete's exposure to hyperthermia could result in pH imbalance induced fatigue (by increased lactate and potassium) they hypothesized that the decreases in performance may also be attributed to glycogen usage, blood glucose availability, noradrenaline production and secretion and the subsequent rise in heart rate. While all participants showed increases in lactate and potassium during the sprint trials, the levels in the hyperthermia group post-trials were lower than in the control groups. This may show that accruing lactate and potassium, both of which typically contribute to the onset of fatigue during exercise, may not actually be a factor in decreasing the performance of intermittent high intensity exercise despite previous research (Drust et al 2005).

PERCEIVED EXERTION

Armada-da-silva et al (2004) looked at the effect of RPE among athletes cycling during a heated, temperature controlled indoor environment (2004). The study hypothesized that hyperthermia would increase psychological perceptions to exercise effort so that the subjects feel they were working harder to achieve comparable times or distances compared to the control. Cardiovascular strain, ventilatory load, muscular contraction sensors, thermal discomfort, pain sensors have all been cited as factors contributing to perceived exertion during exercise (Armada-da-silva et al 2004). The study evaluated these factors through measuring skin and core temperatures after heat treatments and following performances.

Male subjects rested in a sauna prior to cycling performances allowing for the passive heating. Skin temperatures were taken in addition to internal temperatures (using rectal probe thermometers) and assessed with a self-reported thermal comfort scale during exercise. Throughout the performance, two different RPE scores were recorded: one for their overall body and one specific to their legs. To further the study, sixty percent (60%) of the subjects then repeated the performance part of the test with an added face cooling treatment. During the performance, the face was cooled with a mister and recordings were taken of HR, RPE and RPE_{legs}, and core temperature. The Armada-da-Silva et al (2004) study demonstrated the effect that body temperature has on perceived exertion. Because of this, the present study also examined the role of body temperature in perceived exertion in football. When subjects were heated through exercising in a warm, temperature controlled room, the RPE response was a higher level (they felt they were working harder) than if they exercised in a cooler room. The participants were then subjected to a face cooling treatment, reducing skin temperature to 30°C as they were exercising in each environment. Participants who were performing in the heated environment with a face cooling treatment reported a lower RPE than those without face cooling regardless of temperature environment (Armada-da-Silva 2004). Face cooling was therefore found to be an effective tool in reducing RPE when exercising in warm environments.

Few attempts have been made to examine body core temperature response to cooling mechanisms such as face cooling (through a sponge, towel blot, or splash of water), ventilated shoulder pads, and cooling shirts. The small numbers of studies in this area have mainly focused on cyclists and cross country runners, with one study looking at

dogs wearing cooling jackets, finding that temperatures were decreased and exercise performance increased (Duffield et al 2003, Arngrimsson et al 2004, Mundel et al 2007).

PRECOOLING

Pre-cooling has been evaluated in a variety of situations, including cycling, cross country running, and football. Uckert and Joch (2007) found that pre-cooling athletes 20min prior to competition or practice improved performance. The study found that participants who simply performed a warm up outdoors in the heat without the pre-cooling treatment performed less well, owing to hyperthermia of the control subjects.

By allowing the body to reach a slightly lower core temperature prior to exercise the threshold of physiological fatigue and resulting physiological changes will take longer to reach. Pre-cooling results in improvements in performance due to reduced cardiovascular strain, increasing the time to reach fatigue, and improving psychological perceptions. Vaile et al (2008) studied the effect of cold water immersion on cycling performance. The study examined a 30 min activity followed by a soak of 15 minutes in a water bath of one of 5 different temperatures followed by a repeated 30 min activity. Through evaluating blood lactate, core body and skin temperatures, heart rate, and RPE, no significant differences were found in total work between the two treatments. Blood lactate was found to decrease significantly when subjects performed an active recovery rather than any of the cold water immersion bath recoveries in between the 30 min sessions. Cold water immersion was found to decrease the thermal strain and increase cycling performance when compared to an active recovery period in between the 30 min activities (Vaile et al 2008).

Conversely, a study by Schniepp et al (2002) found cold water immersion to be detrimental to repeated cycling performances when compared to a break period of quiet sitting. The results did find that the heart rate of the post-immersion maximal cycling sprint was significantly lower than in the control condition, although average heart rate had a greater decrease in the control condition. Their study suggests that while hyperthermia can impair physical performances, brief breaks with cold-water immersion can also be harmful to performance, despite decreases in core temperature and heart rate (Schniepp et al 2002).

Decreases in performance due to hyperthermia have been demonstrated, while performance enhancements due to passively heating working muscles were also shown (Linnane et al 2004). Passively heating participants through water baths or temperature controlled rooms increased the power output performed in cycling performances due to biochemical muscular adaptations (Linnane et al 2004).

COOLING DEVICES

Arngrimsson et al (2004) examined the efficacy of a cooling vest, which, they argue in many cases is more practical than previous pre-cooling treatments like cold water baths and air cooled rooms. Their study on heat acclimated 5k participants wearing a cooling vest who trained for track events from the 800m to the marathon logging an average of 47(females) to 63(males) miles/week. After a 38 min long warm-up and simulated 5k performance temperature and cardiovascular fatigue were reduced leading to a reduced time recorded for the 5k run. The performance enhancement occurred despite the increased metabolic cost of carrying a cooling vest weighing about 4.5kg (10lbs) (Arngrimsson et al 2004). These results were supported by a previous study

which also found that pre-cooling is effective at improving run time and run distance performances (Uckert and Joch 2007).

Duffield et al (2003) examined the effect of an ice cooling jacket worn by hockey players during repeated sprint performances. As with pre-cooling, it is hypothesized that keeping the body cooler can limit the effects of hyperthermia, reducing performance limitations in a variety of activities. The study examined physically fit men who played field hockey both with a cooling vest and without. An 80-minute long sprint cycling session was performed consisting of 5 second sprint, 55 second recovery cycles in an attempt to mimic a team sport game. A cooling jacket with pockets designed to hold ice or ice packs were worn during one of the two testing sessions over normal athletic clothing.

The study found that there was no significant difference between sessions where participants wore ice cooling vests and when they did not when comparing total work done and power produced. There was also no significant difference in core body temperature found through the length of the test between the two sessions, however a trend was found in the cooling condition for decreased skin temperature. Although there was no significant difference found in the RPE evaluation between the two groups there was another trend found at the half time break for a lower RPE when subjects wore the cooling vest compared to the control, non-cooled session (Duffield et al 2003).

SUMMARY

Psychological benefits, as well as some physiological benefits appear to be present with treatments such as face cooling, misters, precooling, and exercising in a cooler, controlled environment. These benefits are in opposition to athletes exercising

with no treatments, performing their physical activity outdoors, in warmer rooms, or with no treatments (Drust et al 2005, Armada-da-Silva 2004, Duffield et al 2003, Arngrimsson et al 2004, Mundel et al 2007, Godek et al 2006, Hitchcock et al 2007). Psychologically, the rates of perceived exertion were lower, so the athletes felt they were working less hard than the control groups (Duffield et al 2003). Some of the studies additionally showed an increase in the time to fatigue among treatment groups receiving heat alleviation as opposed to control groups, as well as performance benefits (Uckert and Joch 2007, Arngrimsson et al 2004). While most cooling treatments appear to be beneficial to athletes, studies on cold water immersion seem to be debatable in its effect on athletic performance (Schniepp et al 2002, Vaile et al 2008). In addition, passive heating of muscles not to the point of hyperthermia may boost performance (Linnane et al 2004).

CHAPTER II

MATERIALS AND METHODS

SUBJECTS AND EXPERIMENTAL APPROACH

This present study included two groups of veteran college football players in the Football Championship Subdivision (formerly Division I-AA). Four offensive linemen and four defensive linemen were used as participants. All subjects were first-string or second-string players on the Georgia Southern University football team who were apprised of the minimal risks involved with the study and signed University approved medical and consent forms. Subjects were heat acclimated *in situ* practicing in no-pads and half pads for two practices daily for two weeks prior to the study in the month of August. Each participant was given a workout regimen that he was expected to perform throughout the summer and preseason training consisting of resistance training and conditioning drills allowing for a consistent baseline fitness level and acclimation to heat, humidity, and practice intensities. Four participants were randomly selected to receive cold air ventilation during off-field breaks, while the other four did not receive ventilation.

CORE TEMPERATURE PROCEDURES

Prior to the morning practice, the participants met with study administrators to have their height and weight measurements taken, as well as body fat and other brief history (Table 3). Each subject was assigned a number from the CorTemp pill (HQ Inc, Palmetto, FL) that they swallowed. This number was then put into the radiofrequency receiver to identify each pill and its player while on the field, and when the practice was over and data was collected. They each swallowed, according to manufacturer's

directions, a CorTemp pill approximately 3 hours prior to participation in the full-pads scrimmage with the remainder of the team. This time period ensured that the pills were out of the stomach and into the small intestines by the time of the scrimmage to ensure maximum accuracy of radiofrequency readings. As studied in Douglas et al. (2007), gastrointestinal temperature readings are the most accurate devices for assessing core temperature. The ingestible thermistors (IT) were found to be the most valid and acceptable. Temperatures given by the IT devices were not found to be statistically different from rectal body temperature at any of the tested time points (Douglas et al 2007). As per their design recommendations, the IT was ingested at least 1 hour prior to exercise. The use of gastrointestinal pills and hand held receivers has been previously demonstrated to be reliable, accurate, and accepted (Webborn et al 2005).

Previous work has evaluated risk for heat related illness through a change in body heat using two and three compartmental methods. Performing calculations using direct and indirect calorimetry to evaluate the relationship between metabolic heat production versus heat loss involves multiple, simultaneous measurements. Through using a gastrointestinal monitoring method, Howe and Bowden (2007) stated that heat related illness, due to an increase in heat production with an impaired ability to dissipate that heat is preventable through identification, prevention, monitoring of athletes and the environment, and quick response to symptoms. While previous protocols have called for fasts of up to 8 hours prior to competition, not allowing athletes a small breakfast prior to the scrimmage was not practical for our study. Results are noted to reflect this factor that may not contribute significantly to our results (Hitchcock et al 2007).

Prior to the team warm-up which included team drills, radio-frequency receivers were held near the lower back to obtain a baseline temperature post-warm-up. CorTemp sensor temperature readings were displayed on a handheld receiver (CT2000 Miniature Ambulatory Recorder HQ Inc, Palmetto FL). Each participant's core temperature was recorded as they exited the field following each series of plays assuring the readings came during the players most active periods.

RATE OF PERCEIVED EXERTION

In addition to temperature, ratings of perceived exertion (RPE) recordings were taken. A 6-20 RPE Borg scale was used (15 point scale: 6 being "no exertion", 20 being "extreme exertion"). While off the field athletes were asked to point to a number representing how they felt displayed on card containing the RPE scale. Previous studies have evaluated the use of the Borg scale in reporting RPE levels and have found them to be accurate (Mundel et al 2007). Several internal feedback mechanisms were found to influence RPE for regulating core temperature and monitoring how hard one is working; mechanisms responsible for signaling work and effort include muscular, cardiovascular, and respiratory sensors (Mundel et al 2007).

Karavatas and Tavakol et al (2005) studied the reliability of the Borg RPE Scale and found it to be a reliable and accurate measurement tool for the evaluation of perceived exercise intensity during activity. They noted its ability to be safely used in normal, healthy populations for assessing exertion levels. While their study noted differences between genders, there were not significant differences within the same sex and BMI groupings using a RPE-HR criterion-validity coefficient, which they found to be 0.58. An additional study on performance athletes was done by Diafas et al (2007) on

the validity of RPE evaluation on male competitive kayakers. RPE through the Borg scale was found to be reliable and valid for evaluating the intensity level of a physical performance and was additionally suggested for the use of regulating athletes in their activities so as to not overextend themselves, etc.

SHOULDER PAD VENTILATION PROTOCOL

The four subjects who were hooked up to the Temperature Management System (TMS) (Douglas manufacturing Houston, TX) were plugged in on the sidelines immediately following each series of plays. Coil tubing connecting the Temperature Management System (air cooling tank) to the shoulder pads allow for ~40°F (4°C) air to be pumped across the athlete's upper torso and shoulders. The amount of time participants were hooked up to the ventilator varied with the amount of time they were off of the field in between plays in accordance with ball possession, just as it would be in a game.

While the temperature readings were taken prior to athletes being able to drink during breaks, both groups of participants when not on the field were allowed to drink water when necessary for hydration and cooling. Ambient air temperatures, as well as wet-bulb globe temperature for humidity and heat index analysis were taken at the beginning of practice and each half hour for the remainder of the scrimmage. Although some studies suggest that water and other fluids should not be administered at will in an effort to lessen the effect upon core body temperature (Drust et al 2005), the present study evaluates the practicality of the TMS in a game situation where fluids would be given throughout the games and practices. Our subjects therefore were allowed water *ad*

libitum, and no other sports or electrolyte replacement drinks during their rest times off of the field after a play series.

STATISTICAL ANALYSIS

Temperature and RPE analyses were performed using SPSS (Version 14, SPSS Inc, Chicago IL). Practice tapes from the scrimmage were used to document the total playing time for each athlete, and totals for the group.

One-way variance using repeated measures was run to examine the difference in temperatures at RPE over the time of the scrimmage. To compare the two treatments, subject data was run with a paired t-test analyzing any differences between the core temp and RPE with the two groups of subjects. Significance was determined at a level of $p>0.05$.

Statistical power was greatly reduced due to the small number of participants available in our study, a problem experienced in a previous study as well (Hitchcock and Stafford et al 2007). As this was a pilot study, the power should be improved with additional subjects in future studies. While all subjects completed the practice and study protocol, our sample size was limited. The addition of more subjects is anticipated through additional trials for this study.

CHAPTER III

RESULTS

The aim of this study was to determine the physiological value of using air cooling, ventilated shoulder pads to lessen the change in core body temperature and resulting physiological changes that occur in response to hyperthermia potentially resulting in heat illnesses and loss of performance. Our data, however, indicated no significant difference between ventilated and non ventilated groups for core temperature and RPE ($p>0.05$).

Mean core temperature readings varied from 96.0°F to 102.7°F for the ventilated group and 100.7°F to 102.4°F for the control group (Figure 1 and Table 1). The mean RPE for ventilated subjects ranged from 6.25 to 14.5 (Figure 2 and Table 2). For non-ventilated subjects, mean RPE ranged from 6.5 to 18.25 (Figure 2 and Table 2). Significance was found between pre and post ventilation core temperatures among ventilated subjects (Figure 3 and Table 5). A trend found among post ventilation RPE shows a decrease in perceived exertion rates due to a cooling effect of the treatment (Figure 4). Given the small number of subjects and limited statistical power of the study, the trend of a decrease in RPE could be a noted benefit of ventilating athletes with cool air shoulder pads, allowing athletes to perform better.

Prior to the start of, and during, the scrimmage, a sling psychrometer was used to determine ambient air temperature and humidity readings (initial values at 9:00am: 83°F and 100% humidity; start of scrimmage at 9:45am: 86°F and 80% humidity; and the end at 11:20am: 90°F and 64% humidity).

The total amount of time players were active on the field for the whole study period was 188 seconds (3.13 minutes) for the control group and 248 seconds (4.13 minutes) for the ventilated group (Table 4). The control group averaged 39.5 seconds per series and 8.55 seconds per play, while the ventilated group averaged 56 seconds per series and 9.19 seconds per play (Table 4). A play was defined as the period of activity from whistle blow to whistle blow, while a series was defined as the amount of time group was on field for consecutive plays before getting an off-field break. It was during this break that the ventilated group received cold air ventilation while the control group did not.

CHAPTER IV

DISCUSSION

The present study examined scrimmages using full pads as in a game situation. While there may be differences in core body temperature when wearing half-pads as opposed to full pads, only full pads would be allowed in a game. Godek et al (2005) studied sweat rates of athletes exercising in practices with half pads in the morning and full pads in the evening. With heat and humidity readings not significantly different, athletes had a higher core body temperature when wearing full pads than half pads. Attributed to a greater body surface area exposed to the air and better evaporative properties, half pads would be preferable during practices, however not feasible in games. Our study examined full pads during a game situation, and found that there was no significant benefit of using cold air ventilated shoulder pads to lower core body temperature. The psychological benefit of using such cooling systems may be taken into account when using such cooling systems, however.

The results of the present study, as also found in the Duffield et al (2003) study, show that RPE evaluation tended to decrease when there was a cooling treatment given to the subjects, the psychological benefit of using equipment such as cooling vests or ventilated shoulder pads may be present. It is thought that these treatments may be useful and a trend may be found for decreasing the perception of exercise intensity. It is unlikely, however, that such relief can be found during endurance or maximal exercise when combined with hyperthermia and dehydration (Duffield et al 2003).

While this study did not evaluate water intake because of a game-like atmosphere was desired, several other studies have done so (Montain et al 1994, Godek et al 2005,

Nybo et al 2000). With sweat rates averaging 2.1L/hour in football players, attention to the fluid needs of athletes in the summer is vital. Among four different sports, running, soccer, rugby and football, football athletes were reported as having sweated the most, despite the intermittent nature of the sport. Recommendations for fluid replacement are also difficult to achieve with the athletes as their requirements for rehydration must be monitored so as not to induce a state of hyponatremia (Godek and Godek et al 2005). Adequate hydration is one of the most efficient, in addition to one of the most practical positive influences on performance during exercise in the heat (Mountain et al 1994, Godek et al 2005, Nybo et al 2000).

Differences in the ages of athletes and years of playing were not examined. It is not known whether significant differences would be found between first year and veteran, first and second string players who may be likely to enter the season in better physical shape and training status. Veteran players may have also been more accustomed to playing in the heat, and therefore better acclimated to the conditions for football practices and games. A detailed physical conditioning history was not taken from each participant, however it is assumed that athletes followed the given summer work out program.

In addition to the effect of clothing materials and layers in thermoregulation, the colors of the uniforms athletes are wearing may be an important factor in hyperthermia and heat illness prevention. Due to its light reflecting properties, a lighter color jersey may be beneficial in limiting hyperthermia more than a dark, navy blue jersey. In the present study, offense and defense position subjects wore either white or blue mesh jerseys. While this study did not compare the two colors as an influence in core body temperature and perceived exertion, this factor may be indicated in future studies. This

being said, it would not be possible for football teams to only play in light colored jerseys all the time. The practicality of scrimmaging or playing in light jerseys may not be evident, however potentially practice apparel may be adjusted on particularly hot and humid days.

The amount of time that treatment groups were on the field was also different between groups. Other comparable studies evaluating the time period athletes were on field, or the amount of time athletes were exercising intensely were not found through literature review. A statistical analysis on playing times and respective treatment groups, on core body temperature and RPE may be indicated in the future.

Thermoregulation in football athletes has rarely been examined, and within hyperthermia studies, the efficacy of cooling treatments during games has not been evaluated. Despite the lower numbers of athletes, our results (temperature and RPE recordings) were comparable to similar studies done on exercising football players (Hitchcock et al 2007). Temperatures in a similar study on the metabolic cost of football drills and plays varied between about 36.9°C – 38.3°C (98.8°F to 101°F) (Hitchcock et al 2007). Our own study varied from 96.0°F to 102.7°F (36°C-39°C) (ventilated) and 100.7°F to 102.4°F (38°C-39°C) (control). Main differences in temperature may be due to the outdoor environment in our study, as well as the game-situation scrimmage as opposed to simulated drills.

This data will allow athletic programs to evaluate the use and efficacy of air-conditioned shoulder pads to maintain optimal core body temperature in their athletes to maximize their performance in game play. This study is essential to the game of American football as few studies have looked at the sport at all, even fewer on the effects

of equipment or changes to such on the core body temperature and physiology of the athlete.

Practical application of the results of this study would include recommendations for maintaining core body temperature (T_c) at levels optimal for performance through the use of thermoregulatory aids such as cold air ventilated shoulder pads. In addition, evaluation of the psychological benefits of ventilated shoulder pads and their effect on play performance may be indicated in future studies. In future studies, the ability to perform a blind study with both groups being plugged into the ventilator may assure more truthful RPE results. It is recommended that future work includes additional variables such as heart rate and lactate analysis. Future studies should also take pre and post temperature readings in addition to our readings for ventilated subjects.

The purpose of this study was to evaluate the efficacy and practicality of using cold-air ventilated shoulder pads in alleviating the physiological and psychological effects to performance caused by hyperthermia. While no significant change was found using the temperature management system in core body temperature or in RPE, it would appear that the most beneficial way to prevent heat related illnesses caused by high intensity exercise in the heat and humidity experienced in the southeast continues to be monitoring of the athletes by support staff, and sufficient preparation of the athletes.

Recommendations from the results of this study include several well known principles of athletic conditioning. Building a solid fitness base so the body is up to the tasks being asked of it not only cardiovascular efficiency but also in sweat and heat loss effectiveness should be of primary importance for decreasing heat-illness risk. Along with physical conditioning and hydration, becoming sufficiently well acclimated to the

environment remains highly effective in reducing the risk of heat related illnesses and performance decreases (Wendt et al 2007, Selkirk and McLellan 2001, Cheung and McLellan 1998, Mueller and Colgate 2008, Hitchcock et al 2007).

Ensuring athletes are well hydrated through practice and have opportunity to rest are additionally of high importance (Francis and Feinstein et al 1991 Godek and Godek et al 2005). Some programs may consider implementing a weigh-in before and after practices to assess athlete hydration levels, recommending salt and electrolyte intake may be indicated as well. Urine specific gravity may be also taken to evaluate hydration status of players, particularly those who find it difficult to maintain healthy hydration levels.

Although most teams require a physical, making sure the athletes are medically capable of the demands of the sport is crucial to decreasing health risk. Monitoring of athletes for signs of heat illness such as nausea, fatigue and/or weakness, rapid pulse (strong or weak), cramping, and in-coordination as well as profuse or lack of sweating by team trainers, coaches, and medical personnel may assist in catching a potential problem early. On particularly hot and humid days, athletes may benefit from either postponing practice or cancelling practice all together, or having access to shade, fans, and face cooling systems such as misters. If an athlete becomes overheated, placing them in an ice bath, administering alcohol on the skin for rapid cooling, and seeking immediate medical attention to lessen the risk of serious illness are all recommended. Additional recommendations found are to intermix longer periods of rest after more intense activity. Allowing room at the end of practices, when ample rest and probably cooling treatments are available, for conditioning may be beneficial (Hitchcock et al 2007).

REFERENCES

- Arngrimsson, Sigurbjorn A. Darby S. Petitt, Matthew G. Stueck, Dennis K. Jorgensen, Kirk J Cureton. "Cooling vest worn during active warm-up improves 5-km run performance in the heat." *Journal of Applied Physiology*. 2004. 96: 1897-1874.
- Armada-da-Silva, J. Woods, D.A. Jones. "The effect of passive heating and face cooling on perceived exertion during exercise in the heat." *European Journal of Applied Physiology*. (2004) Vol 91: 563-571.
- Brotherhood, JR. "Heat stress and strain in exercise and sport." *Journal of Science Medicine and Sport*. 2008 February, 11(1): 6-19.
- Brisson BR, Boisvert P, Peronnet F, Quirion A, Senecal L. "Face cooling-induced reduction of plasma prolactin response to exercise as part of an integrated response to thermal stress." *European Journal of Applied Physiology*. 1989;58(8):816-20.
- Casa J. Douglas, Shannon M. Becker, Matthew S Ganio, Christopher M Brown, Susan W Yeargin, Melissa W. Roti, Jason Siegler, Julie A Blowers, Neal R Glaviano, Robert A Huggins, Lawrence E Armstrong, Carl M Maresh. "Validity of Devices that Assess Body Temperature During Outdoor Exercise in the Heat." *Journal of Athletic Training*, 2007; 42(3), pp 333-342.
- Cheung, Stephen, and Tom M McLellan. "Heat Acclimation, aerobic fitness, and hydration effects on tolerance during uncompensable heat stress." *Journal of Applied Physiology*. May 1998. Volume 84(5): 1731-1739.

- Chin Leong Lim, Byrne Chris, Lee KW Jason. "Human Thermoregulation and Measurement of Body Temperature in Exercise and Clinical Settings." *Annals Academy of Medicine*. April 2008, Volume 37(4).
- Cooper Jr, Earl R, Michael S Ferrara, Steven P Broglio. "Exertional Heat Illness and Environmental Conditions During a Single Football Season in the Southeast." *Journal of Athletic Training*. 2006:41(3):332-336.
- Coris, Eric E, Ramirez Arnold M, Van Durme, Daniel J. "Heat Illness in Athletes: The Dangerous Combination of Heat, Humidity, and Exercise." *Journal of Sports Medicine*. 2004, Volume 34 (1): 9-16.
- Diafas, Vasilios, Konstantinos Chrysikopoulos, Vassiliki Diamanti, Vihren Bachev, Socratis Kaloupsis, Mathaios Polykratis and Athanasios Villiotis. "Rating of Perceived Exertion in Kayaking Ergometry." *Kinesiology* 39(2007) 1:21-27
- Dohi, Keiichiro, William J Kraemer, Andrea Mastro. "Exercise increases prolactin-receptor expression on human lymphocytes." *Journal of Applied Physiology*. (2003) 94:518-524.
- Drust, B, P. Rasmussen, M. Mohr, B. Nielsen and L. Nybo. "Elevations in core and muscle temperature impairs repeated sprint performance." *Acta Physiol Scand* 2005, 183, 181-190
- Duffield, R, B Dawson, D Bishop, M Fitzsimmons, S Lawrence. "Effect of wearing an ice cooling jacket on repeat sprint performance in warm/humid conditions." *British Journal of Sports Medicine*. 2003 37: 164-169.

- Edwards AM, Mann ME, Marfell-Jones MJ, Rankin DM, Noakes TD, Shillingto DP. "Influence of moderate dehydration on soccer performance: physiological responses to 45 min of outdoor match-play and the immediate subsequent performance of sport-specific and mental concentration tests." *British Journal of Sports Medicine*. 2007 Jun;41(6):385-91.
- Epstein, Yoram, Daniel S Moran. "Thermal Comfort and Heat Stress Indices." *Industrial Health*. 2006 44: 388-398.
- Fortney Sm and Vroman NB. "Exercise, performance, and temperature control: temperature regulation during exercise and implications for sports performance and training." *Journal of Sports Medicine*. 1985 January. Vol 2(1): 8-20.
- Francis K, Feinstein R, Brasher J. "Heat Illness in football players in Alabama." *Alabama Medicine*. 1991 Mar Volume 60 Issue (9):10-4.
- Gavin, TP. "Clothing and thermoregulation during exercise." *Journal of Sports Medicine*. 2003;33(13):941-7.
- Geladas N and E.W. Banister. "Effect of cold air inhalation on core temperature in exercising subject under heat stress." *Journal of Applied Physiology*. 1988 Vol 64(6) 2381-2387.
- Geor, Raymond, and Laura McCutcheon. "Hydration effects on physiological strain of horses during exercise-heat stress." *Journal of Applied Physiology*. (1998) Vol 98: 2042-2051.

- Geor, Raymond J. Laura Jill McCutcheon, Gayle L Ecker, and Michael I Lindinger. "Heat storage in horses during submaximal exercise before and after humid heat acclimation." *Journal of Applied Physiology*. Vol. 89, Issue 6, 2283-2293, December 2000.
- Godek, Sandra Fowkes, Arthur R Bartolozzi, Richard Burkholder, Eric Sugarman, Gary Dorshimer. "Core Temperature and Percentage of Dehydration in Professional Football Lineman and Backs During Preseason Practices." *Journal of Athletic Training*. (2006) 41 (1): 8-17.
- Godek, Sandra Fowkes. Joseph J. Godek, Arthur R. Bartolozzi. "Hydration Status in College Football Players during Consecutive Days of Twice-a-Day Preseason Practices." *The American Journal of Sports Medicine*. November 2005: 33(6): 843-850.
- Godek, S Fowkes, A R Bartolozzi, J J Godek, "Sweat rate and fluid turnover in American football players compared with runners in a hot and humid environment." *British Journal of Sports Medicine*. (2005) 39: 205-211
- Godek, Sandra Fowkes, Joseph J. Godek, Arthur R Bartolozzi. "Thermal Responses in Football and Cross Country Athletes During Their Respective Practices in a Hot Environment." *Journal of Athletic Training*. (2004) 39: 235-240
- Godek, Sandra Fowkes; Bartolozzi, Arthur R.; Kelly, Michael. "Changes in Blood Electrolytes and Plasma Volume in NFL Football Players During Pre-season Training." *Medicine & Science in Sports & Exercise*:Volume 36(5) Supplement May 2004. p 49.

- Hasegawa, Hiroshi. Tadashi Takatori. Takashi Kormura, and Masahiro Yamasaki. "Wearing a Cooling Jacket During Exercise Reduces Thermal Strain and Improves Endurance Exercise Performance In A Warm Environment." *Journal of Strength and Conditioning Research*. 19(1), 122-128. 2005.
- Hitchcock, Kristen M., Melinda L Millard-Stafford, Jeremy M Phillips, Teresa K. Snow. "Metabolic and Thermoregulatory Responses to a Simulated American Football Practice in the Heat." *Journal of Strength and Conditioning Research*. 2007: 21(3): 710-717.
- Howe, Allyson S., Barry P Boden. "Heat Related Illness in Athletes." *The American Journal of Sports Medicine*. 2007: 35:1384-1395.
- Jay, Ollie, Louise M Garipey, Francis D Reardon, Paul Webb, Michael B Ducharme, Tim Ramsay, Glen P. Kenny. "A three-compartment thermometry model for the improved estimation of changes in body heat content." *American Journal of Physiol Regul. Integr. Comp Physiology*. 2006: 292:R167-R175.
- Karavatas, SG, Tavakol, K. *Concurrent Validity Of Borg's Rating Of Perceived Exertion In African-American Young Adults, Employing Heart Rate As The Standard*. The Internet Journal of Allied Health Sciences and Practice. January 2005. Volume 3 Number 1.
- Kulka TJ, Kenney WL. "Heat balance limits in football uniforms." *Physician Sportsmed*. 2002;30(7):29-39.

- Latzka, William A., Michael N. Sawka, Scott J. Montain, Gary S. Skrinar, Roger A. Fielding, Ralph P. Matott, and Kent B. Pandolf. "Hyperhydration: thermoregulatory effects during compensable exercise-heat stress." *Journal of Applied Physiology*. Vol. 83, No. 3, pp. 860-866, September 1997.
- Linnane D.M., R.M. Bracken, S. Brooks, V.M. Cox, D. Ball. "Effects of hyperthermia on the metabolic responses to repeated high-intensity exercise." *Eur J Applied Physiology* (2004) Vol 93. pp 159-166.
- Low, David, Tim Cable, and Alison Purvis. "Exercise thermoregulation and hyperprolactinaemia." *Ergonomics*. (2005) Vol 48. pp 1547-1557.
- McCutcheon Laura Jill, Raymond J Geor, Gayle L Ecker and Michael I. Lindinger. "Equine sweating responses to submaximal exercise during 21 days of heat acclimation." *Journal of Applied Physiology*. November 1999. Vol. 87, Issue 5, 1843-1851.
- Montain, Scott J, Michael N Sawka, Bruce S Cadarette, Mark Quigley, James M McKay. "Physiological tolerance to uncompensable heat stress: effects of exercise intensity, protective clothing, and climate." *Journal of Applied Physiology*, 1994. Vol 77 (1): 216-222.
- Mueller, Frederick O, and Bob Colgate. "Annual Survey of Football Injury Research." National Center for Catastrophic Sport Injury Research. February 2008. URL Available from: <http://www.unc.edu/depts/nccsi/SurveyofFootballInjuries.htm>.
- Mündel, Toby, Jenny King, Esther Collacott, David A. Jones. "Drink temperature influences fluid intake and endurance capacity in men during exercise in a hot, dry environment" *Experimental Physiology*. 2006: 91(5): 925-933.

- Mündel, Toby, Sabrina J. Bunn, Paula L. Hooper, David A. Jones. “The effects of face cooling during hyperthermic exercise in man: evidence for an integrated thermal, neuroendocrine and behavioural response.” *Experimental Physiology* 92(1):187-195.
- Naylor, J.R., W. M. Bayly, P. D. Gollnick, G. L. Brengelmann and D. R. Hodgson “Effects of dehydration on thermoregulatory responses of horses during low-intensity exercise.” *Journal of Applied Physiology*. Vol 75, Issue 2 994-1001.
- Nybo, Lars, Thorbjorn Jensen, Bodil Nielsen, Jose Gonzalez-Alonzo. “Effects of marked hyperthermia with and without dehydration on VO₂ kinetics during intense exercise.” *Journal of Applied Physiology*. 2004. 90: 1057-1064.
- Pascoe DD, Shanley LA, Smith EW. “Clothing and exercise. I: Biophysics of heat transfer between the individual, clothing and environment.” *Journal of Sports Medicine*. July 1994, 18(1): 38-54.
- Pascoe DD, Bellinger TA, McCluskey BS. “Clothing and Exercise. II. Influence of Clothing during exercise/work in environmental extremes.” *Journal of Sports Medicine*. 1994 August; 18(2): 94-108.
- M. N. Sawka, M.N. , A. J. Young, W. A. Latzka, P. D. Neuffer, M. D. Quigley and K. B. Pandolf “Human tolerance to heat strain during exercise: influence of hydration.” *Journal of Applied Physiology*. 1992. Vol 73, Issue 1 368-375.
- Schniepp, Jason, Campbell Teri, Powell, Kasey, and Pincivero Danny. “The effects of Cold-water immersion on Power Output and Heart Rate in Elite Cyclists.” *The Journal of Strength and Conditioning Research*. November 2002. Volume 16(4): pp561-566

- Selkirk, Glen A, and Tom M. McLellan. "Influence of aerobic fitness and body fatness on tolerance to uncompensable heat stress." *Journal of Applied Physiology*. November 2001. 91(5):2055-2063.
- Shirreffs SM, Aragon-Vargas LF, Charmorro M, Maughan RJ, Serratos L, Zachwieja JJ "The sweating response of elite professional soccer players to training in the heat." *International Journal of Sports Medicine*. March 2005 Vol. 26(2):90-5.
- Ückert, Sandra, Winfried Joch. "Effects of warm-up and precooling on endurance performance in the heat." *British Journal of Sports Medicine*. 2007: 41:380-384
- Webborn, N, M.J. Pierce, P.C. Castle, and V.L Goosey-Tolfrey. "Effects of two cooling strategies on thermoregulatory responses of tetraplegic athletes during repeated intermittent exercise in the heat." *Journal of Applied Physiology*. 2005: 98: 2101-2107.
- Vaile J, Halson S, Gill N, Dawson B. "Effect of cold water immersion on repeat cycling performance and thermoregulation in the heat." *Journal of Sports Science*. March 2008: 26(5): 431-40
- Wailgum TD, Paolone AM. "Heat tolerance of college football lineman and backs." *Physician Sportsmed*. 1984; 12(5):81-86.
- Watson G, Casa DJ, Fiala KA, Hile A, Roti MW, Healey JC, Armstrong LE, Maresh CM. "Creatine use and exercise heat tolerance in dehydrated men." *Journal of Athletic Training*. Jan-March 2006. Volume 41, Issue 1: Pg 18-29.
- Wendt, Daniel, van Loon Luc J.C.; Wouter D. van Marken, Lichtenbelt. "Thermoregulation during Exercise in the Heat: Strategies for Maintaining Health and Performance" *Journal of Sports Medicine*. November 2007. Volume 37 (8): 669-682(14)

Yeargin SW, Casa DJ, Armstrong LE, Watson G, Judelson DA, Psathas E,

Sparrow SL. "Heat acclimatization and hydration status of American football players during initial summer workouts." *Journal of Strength and Conditioning Research*. 2006 Aug;20(3):463-70.

FIGURES AND TABLES

Figure 1:

Mean Core Temperature of Ventilated (V) and Non Ventilated (NV) Athletes Per Time of Recording of Recording

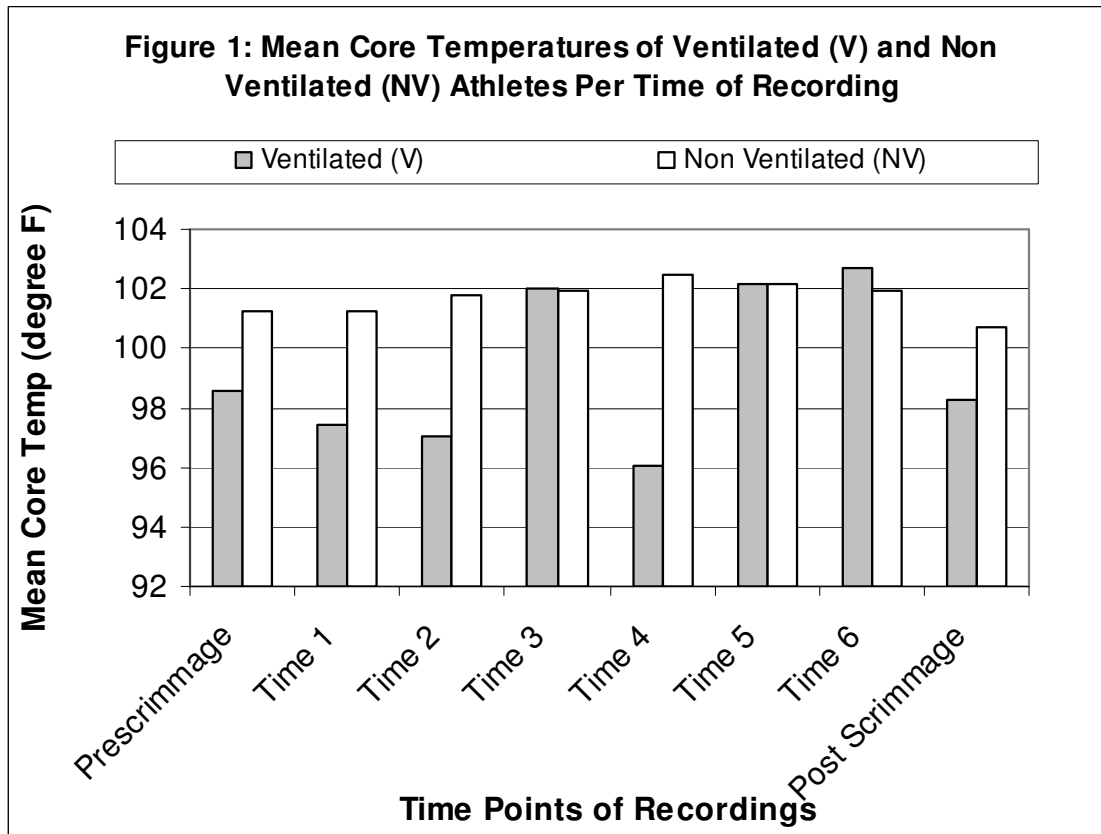


Figure 2:

Mean Rate of Perceived Exertion (RPE) for Ventilated and Non Ventilated Athletes Per Time of Recording

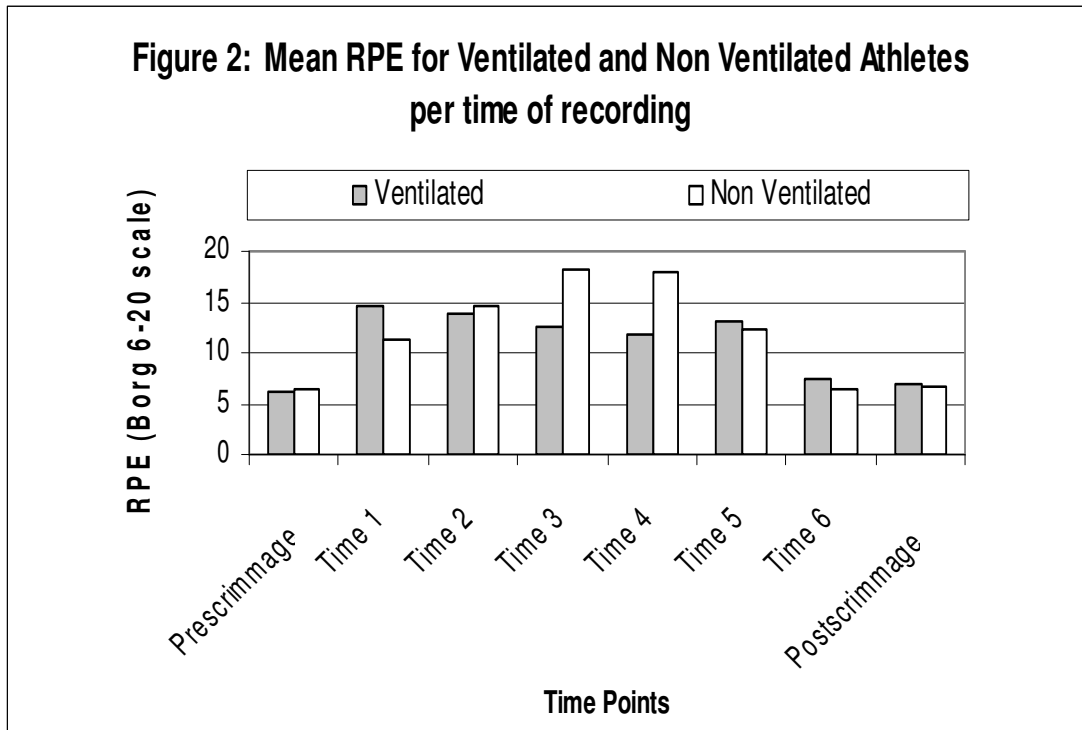
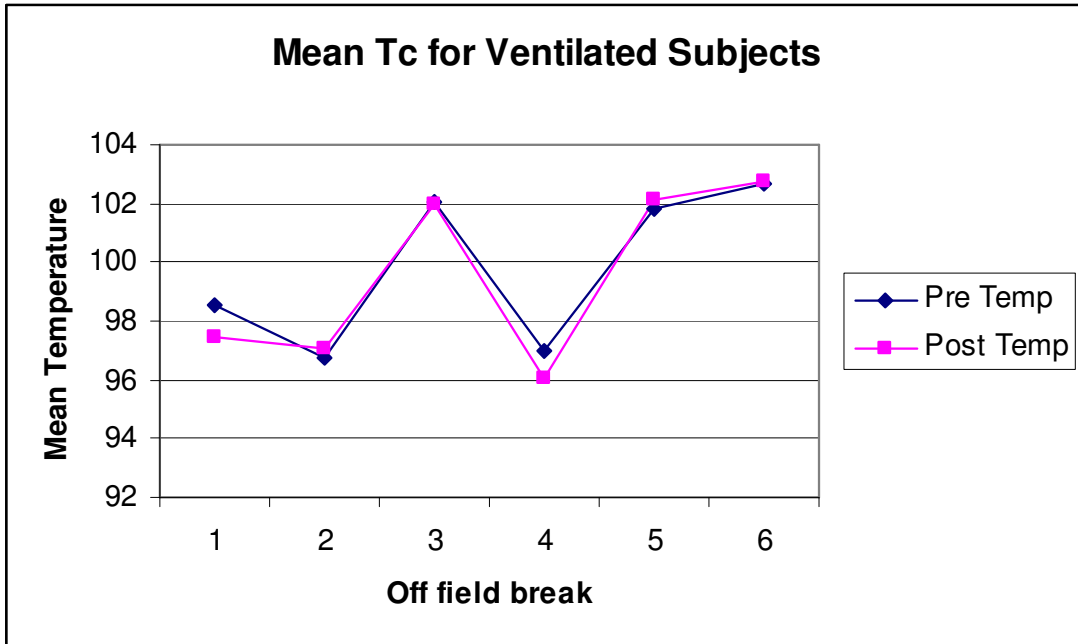


Figure 3:

Paired Samples Statistics on Core Body Temperature for Ventilated Subjects (Pre and Post Ventilation Values Shown)



Temperatures in degree Fahrenheit

Figure 4

Paired Samples Statistics on Ventilated Subjects Pre and Post Ventilation during off-field breaks

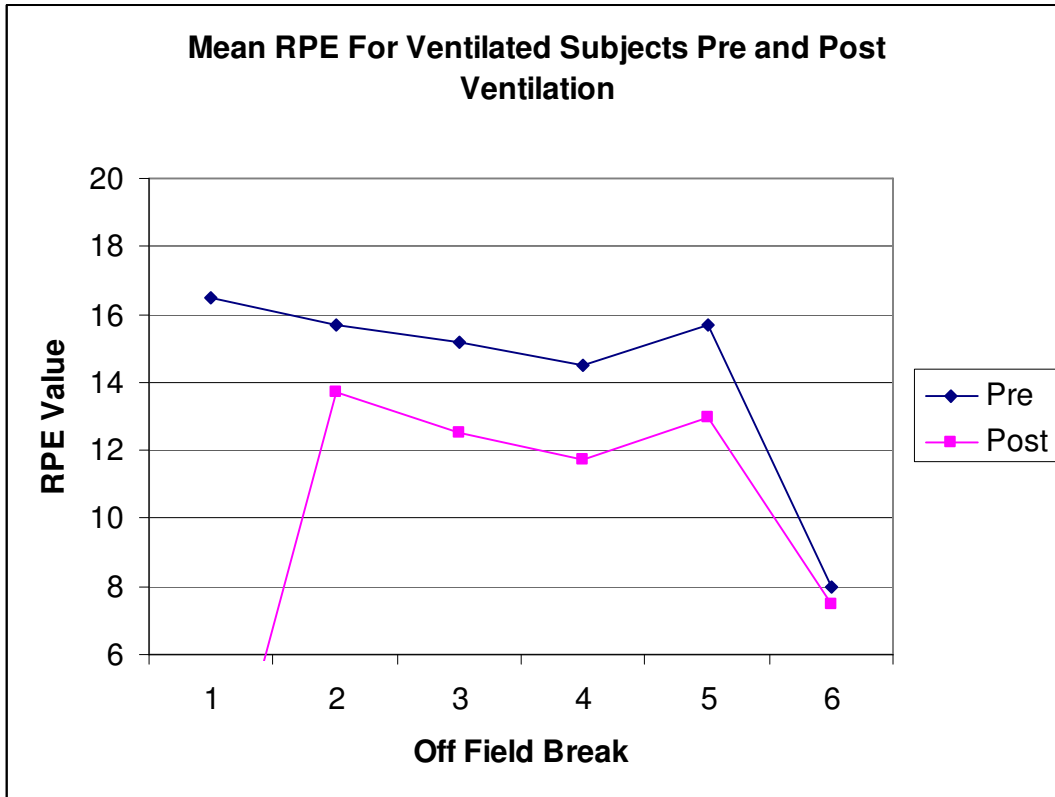


Table 1

Means for core body temperature between ventilated and non ventilated subjects per time point

	Ventilated	(Control) Non-ventilated
Initial	98.57°	101.28°
Time 1	97.44°	101.28°
Time 2	97.07°	101.76°
Time 3	102.00°	101.97°
Time 4	96.06°	102.49°
Time 5	102.14°	102.17°
Time 6	102.72°	101.93°
Post	98.25°	100.74°

Temperatures in degrees Fahrenheit

Table 2

Means for Rate of Perceived Exertion (RPE) between ventilated and non-ventilated subjects per time point

	Ventilated	(Control)Non-Ventilated
Initial	6.25	6.50
Time 1	14.50	11.33
Time 2	13.75	14.67
Time 3	12.53	18.25
Time 4	11.75	18.00
Time 5	13.00	12.3
Time 6	7.50	6.50
Post	7.00	6.75

Based on standard 15-Point Borg Scale as found in Appendix C

Table 3

Demographic data of subjects

Jersey #	Group	Height (in)	Weight (kgs)	% Body Fat	Age
90	V	73	131.9	21.7	21
99	V	74	115.09	19.6	20
70	V	75	128.64	22.6	20
77	V	75	123.72	27	23
Average	V	74.25	124.83	22.7	21
44	NV	73	128.9	28.9	23
97	NV	75	110.63	15.3	21
69	NV	76	116.72	18.2	22
62	NV	76	121.09	18.3	23
Average	NV	75	119.34	20.4	22

Table 4

Playing time per group during the scrimmage

	Control (Non Ventilated)	Ventilated
Total		
Seconds Played	188	248
Minutes Played	3.13	4.13
Average of seconds		
per series	39.5	56
per play	8.55	9.19

Play-amount of time of active playing from whistle blow to whistle blow

Series-amount of time group is on field for consecutive plays before getting a break

Table 5

Paired Sample Test of Pre and Post Scrimmage Temperature and Pre and Post

Scrimmage RPE

	Significant Difference (2-tailed)
Prescrimage – Postscrimage Temperature	.004
RPE	.763

Table 6

Descriptive Statistics on Rate of Perceived Exertion of Non Ventilated Athletes Per Time

Point

	N	Min	Max	Standard Deviation
RPEpre	4	6	7	0.58
RPE1	3	6	15	4.72
RPE2	3	12	17	2.51
RPE3	4	14	20	2.44
RPE4	4	16	20	1.63
RPE5	3	6	17	5.67
RPE6	3	6	12	3
RPEpost	4	6	8	0.96

Table 7

Paired Samples Statistics on Core Body Temperature for Ventilated Subjects

	Mean	Standard Deviation
Time point 1 pre vent	98.56	4.56
Time point 1 post vent	97.44	7.23
Time point 2 pre vent	96.79	8.48
Time point 2 post vent	97.06	8.12
Time point 3 pre vent	102.04	0.588
Time point 3 post vent	102	0.29
Time point 4 pre vent	96.97	9.2
Time point 4 post vent	96.06	10.99
Time point 5 pre vent	101.81	0.8
Time point 5 post vent	102.14	1.01
Time point 6 pre vent	102.64	0.37
Time point 6 post vent	102.72	0.73

Temperatures in degrees Fahrenheit

Table 8

Paired Samples Statistics on RPE of Ventilated Subjects

	Mean	Std Deviation
RPE1a	16.5	2.38
RPE1b	14.5	4.04
RPE2a	15.7	3.1
RPE2b	13.7	4.34
RPE3a	15.2	3.1
RPE3b	12.5	1.9
RPE4a	14.5	3.3
RPE4b	11.75	2.36
RPE5a	15.7	1.7
RPE5b	13	1.82
RPE6a	8	1.8
RPE6b	7.5	1.7

APPENDICES

APPENDIX A

PROBLEM/PURPOSE OF STUDY

There were 33 football fatalities due to heat stroke from 1995 to 2007 including professional, college and high school players (Mueller and Colgate 2007). Numerous systems and ideas have been presented to assist in the prevention of heat related illness and death. It is the goal of this study to determine the efficacy of shoulder pad ventilated cooling systems in lowering core body temperature of athletes practicing in the heat.

RESEARCH HYPOTHESIS

1. Core temperature will be significantly lower when subjects are given ventilated shoulder pads and cold air treatment than without ventilation.
2. Rate of Perceived Exertion (RPE) reporting will be lower in subjects who receive ventilation than in subjects who do not.

DEFINITIONS

1. Heat Illness- a term used to describe any of the four illnesses and conditions below caused by overexposure to heat. Humidity can also be a factor.
 - a. Heat stress- synonymous with heat illness
 - b. Heat cramps- muscle spasms or pain occurring during heavy exercise
 - c. Heat exhaustion- a condition involving symptoms such as heavy sweating, rapid breathing and a fast, weak pulse, a precursor to heat stroke.
 - d. Heat stroke- life threatening condition during which body temperature rises to 106°F or higher. Symptoms include dry skin, rapid, strong pulse and dizziness.

2. Humidity, relative- a ratio expressed as a percentage of the maximum amount of water air could hold. High humidity decreases evaporation leading to dehydration and overheating.
3. Heat acclimatization- defined as the adaptive changes by the body due to time in an environment that improves the body's tolerance to heat.
4. Healthy-free from illness, disease or injury of the body, mind, and being.
5. Thermoregulation-the physiological steps taken by the body to maintain an internal temperature of around 37° C or 98.6° F.

ASSUMPTIONS

1. Participants are honest in reporting their rate of perceived exertion based on how they actually feel
2. Participants will not provide false RPE data based on whether or not they are plugged into the cold air ventilator (Temperature Management System, TMS).
3. Cor Temp 2000 (HQ Technologies, Inc) pills are ingested and reach the gut in the recommended 4-6 hours prior to data collection.
4. Each athlete's heat acclimatization, cardio-respiratory fitness, and playing efforts are not significantly different.
5. Due the similarity in player position, all athletes performed a similar warm-up routine.

DELIMITATIONS

1. The color of the jerseys worn may have an effect on heat retention as offense and defense will wear each wear either blue or white.

2. The amount of acclimatization and cardiovascular fitness of subjects may be significantly different.
3. All subjects in study are from the same football team.
4. Hydration levels of individuals may affect body's ability for thermoregulation.

BIASES

Though we will not monitor the fluid intake and temperatures of the athletes, we know that only water will be available, no electrolyte-replacement sports drinks are given during scrimmages. Though it is possible that hydration will play a part in our results, in a practical application standpoint, our study attempts to be as game-like as possible where fluid intake would not be strictly measured but administered.

One further possible complication through the results of this study is the potential that for some elite athletes who push themselves, the perception that they are not working as hard could be harmful as they may push themselves too much and risk heat illness development. We expect this to be rare and through the utilization of athletic trainers and other support staff, health risks should be minimized.

APPENDIX B

EXTENDED REVIEW OF LITERATURE

Numerous previous studies examined different aspects of exercising and heat related issues. Hydration and hormonal levels, different amounts of clothing, and external climate conditions are all factors that have been manipulated to determine the optimal conditions for exercise.

HYDRATION

Hydration studies involving dehydration, hypohydration and euhydration have been completed to evaluate the physiological response during exercise. Several studies have found the negative effect that improper hydration has had on exercise performance (Montain et al, Edwards et al 2007). Montain et al notes that hypohydration was superior to fitness levels in determining when exhaustion due to increases in core temperature occurred in association with other potentially smaller factors such as clothing, intensity and climate (2005). Hypohydration strongly dictates the level to which core body temperature can rise, decreasing the tolerance to rising core temperatures (Sawka et al 1992).

In response to extreme heat, fluid and electrolyte loss can occur through sweat, change in pH, metabolic function, neuromuscular activity, and less efficient maintenance of core temperature (Godek et al 2005). Sweat loss in summer environments have been noted to reach 2L per hour, making it exceedingly difficult for the body to maintain thermoregulation and remain hydrated and maintain electrolyte balance (Godek and Godek et al 2005). The inability to rehydrate after sweat loss has been noted in other sports as well, including soccer, where fluid and electrolyte loss may decrease

performance of top athletes (Shirreffs et al 2005). While other athletes are affected by fluid loss through sweat from exercising on hot days, Godek and Godek et al found that the rates at which football players are sweating (2.1L/hr) were higher than in soccer players, rugby players, and runners at 1.2-1.7L/hr, 1.8 L/hr and 1.77L/hr respectively. This was found despite data suggesting football athletes were intermittently active for a total of 20 minutes out of a 1 hour practice session. Body weight and clothing worn were suggested causes for the major differences in sweat rate. Coris et al (2004) states that for every 1% of body weight lost through sweat evaporation and fluid loss, the body may experience a rise in temperature of 0.15-0.2°C due to the ineffectiveness of transferring heat from the body.

Godek et al (2005) noted that athletes were more likely to become dehydrated throughout a series of practice days as the amount of fluid lost was difficult to replace before the next practice. This compounded the effect of dehydration in a series of daily practice. In addition, the availability of very cold water (over lukewarm or cool) was thought to make a difference in preventing dehydration. Because small school budgets may make it difficult to afford to administer electrolyte replacement sports drinks, let alone cooling devices and fans to their athletes during practices and games supplying cold water with enhanced drinkability may increase hydration success. Therefore, this finding is important information for coaches and trainers to combat dehydration in their athletes in hot environments (Godek et al 2005, Godek et al 2004). It should be noted, however, that supplying just water without the additional electrolytes lost during sweat may not be as effective as sports drinks in reducing cramping and other issues. Cheung and McLellan (1998) also found that accessibility to water was a practical and successful

method of increasing the body's tolerance to heat. They found that a 2-3% decrease in bodyweight was enough to impair performance and the body's efficiency at transferring heat to the environment to keep core temperatures low (Cheung and McLellan 1998).

Geor et al (1998) found similar results and supported that while hydration is essential to thermoregulation, hyper-hydrating prior to an exercise bout had no significant benefit. In addition, cardiac output, ability and amount of sweat produced, and stroke volume reductions were not found in cases where hydration was maintained through water and carbohydrate-electrolyte therapy (Geor et al 1998). This work was supported by Latzka et al (1997) on human subjects, finding no benefit of hyperhydration on thermoregulation and performance advantage. The ability to sweat more efficiently after a 21 day heat and humidity acclimation period while conserving Na⁺ ions during exercise emphasizes the role of acclimatization on thermoregulation and performance (McCutcheon et al 1999).

Nybo et al (2000) found that the effects of hyperthermia reduction of VO_{2max} among euhydrated and dehydrated groups were similar. Further, they noted a lower stroke volume and therefore reduced aerobic capacity in their participants increasing the HR_{max} when hyperthermia was coupled with dehydration as well as euhydration. Their results were similar to previous studies finding a 27% decrease in VO_{2max} (Pirnay et al 1970, Nybo et al 2000). Nybo et al found a 26ml reduction in stroke volume, a 4 L/min reduction in cardiac output and a 16% decrease in VO_{2max} each of which would lead to a decline in performance on the field due to fatigue. Their examination of heart rate was instrumental in demonstrating the tachycardia effect of hyperthermia on exercise, which was found in both hyperthermia/euhydration and the hyperthermia/dehydration. The

heart rates of the athletes, though working out at a submaximal level, were very close to a maximal heart rate (about 190 bpm).

HORMONAL CHANGES

Hormonal changes such as increases in cortisol, prolactin, catecholamines (such as adrenaline, noradrenaline and other neurotransmitters like dopamine) levels have been shown to occur following exercise (Linnane et al 2004). Plasma ammonia levels were found to increase following repeated 30-second cycling sprints after which each 1 increase in temperature resulted in a 6% increase in power output during the immediately following sprint cycle. After the initial follow-up cycle, additional sprint cycles did not show significant improvement in performance. The increased muscular temperature and resulting increased rates of cross bridge cycling is supported by increased plasma ammonia levels found in the blood after cycle sprints. Glucose and cortisol levels, and increases in catecholamine levels all suggest metabolic stimulation due to increases in body temperature. Linnane et al (2004) found that these hormonal stimulations signal different fiber and energy system engagements, namely glycogen usage. Sports such as football, involving sprints or quick bursts of activity rely upon glycogen for energy.

Mundel et al (2007) examined the role of face cooling on hormonal response to hyperthermia and its role in thermoregulation. Mundel et al (2007) evaluated different levels of prolactin to assess hormonal response to intense exercise. Prolactin is secreted by the body in response to physical stress and can counteract dopamine. Physical activity typically raises prolactin levels. Their study showed that an increase in core temperature stimulates prolactin, but found that with face cooling, there was a decrease in prolactin secretion. They concluded that face cooling was effective at lowering temperature and

decreasing the hormonal response to intense exercise, which supported previous work (Brisson et al 1989). Whether a decrease in prolactin secretion was a result of an overall decrease in skin temperature (in this case, face skin temperature was kept below 28°C during exercise) or a decrease in brain temperature is debated, more research is necessary. The study allows a practical prescription for hot weather exercising, as it is easier to cool just the face than full body cooling to achieve a decrease in prolactin (Mundel et al 2007).

Watson and Carson et al studied creatine supplementation in athletes and its role in increasing the risk of injury and heat related illnesses (2006). While the study examined the effects of short term creatine supplementation, results of long term use are not known. The use of creatine in athletics and the risks associated with its use in a medical, as well as physiological way with exercise and performance are not well known in association with hyperthermia.

CLOTHING

While various uniforms can affect core body temperature (from adding layers to play in cold climates or fewer layers in warm temperatures), in football the minimum of pads and jersey/pants must be worn for protective and identification purposes. Advances in fabric technologies have made it possible to include moisture wicking properties in uniforms to facilitate evaporation of sweat and assist in body heat loss when playing in hot and humid environments (Pascoe et al 1994). The effect of the amount of clothing and type of fabric on performance appears debatable as some studies have not found a difference in its ability to assuage increases in core body temperature. Gavin (2003) found that while in hot weather, the amount or type of fabric does not change

thermoregulatory abilities of the body, shielding over the skin from injury and protection from radiant heating may be beneficial.

While working out in an informal setting or casual practice athletes may have some flexibility in determining their attire, clearly uniforms must be worn during games and scrimmage events. Athletes wearing even the minimal uniform requirements may still have trouble dissipating heat at a rate which the body can maintain a safe core temperature (Montain et al 1994, Hasegawa et al 2005, and Cooper et al 2006). The use of cold air plug-ins for the ventilated shoulder pads may be indicated for improving the air flow over the body of the athlete which may keep them cooler.

Montain et al (1994) reported on the impact of clothing on the time to reach a core temperature at which exhaustion from heat strain occurs in firefighters. It was found that the exhaustion occurred in less time for the fully clothed group over the partially clothed group in a tropical climate (35°C dry bulb, 50% relative humidity, and a wind of 2.2 m/s).. The full clothing time to exhaustion was 46±11 min. while partial clothing time to exhaustion was 88±28 min. These results suggested that the less clothing worn during extreme temperatures when exercising promotes a lower core body temperature, which would not be practical for their main audience of firefighters since protective clothing must be worn.

Similarly, as previously mentioned athletes must retain a minimum uniform of pads, jersey, pants, etc to play safely and legally. Montain et al (1994) found that when the neck, face and hands that are left exposed to the environment, the body core temperature was not significantly different than the core body temperature at exhaustion of subjects who were unclothed. Their results showed a decrease in physiologic capacity

with head, neck, and hands covered resulting in increases in temperature and reductions in blood volume, cardiac filling and mean arterial pressure. Covering these areas of the body reduces evaporative surface area by 12% (Montain et al 1994).

A study on the effect of wearing half versus full pads on core body temperatures found that only 0.2°C separated the core body temperatures seen in morning practice times (with a relative humidity of 64.9%), than in afternoon practices (with a RH of 43%) despite ambient air temperature in the afternoon being higher (Godek et al 2005). The reasonable core temperatures noted in their study were attributed to the players wearing half-pads, allowing for heat dissipation across the skin surface (Godek et al 2005). These findings may be more applicable to preseason conditioning where athletes would be able to forego wearing full pads to decrease the risk of heat strain; however, half pads would not be used in scrimmages or intercollegiate games.

Few situations actually require a person to be fully clothed, such as firefighters and soldiers. In athletics, leaving the face, neck, and hands uncovered makes the body much better off at thermoregulation and decreasing the risk of reaching exhaustion due to heat strain. While football uniforms do cover most of the body, the sweat glands located through the hands, neck and face, when uncovered may be able to achieve similar evaporative and heat transferring properties, lessening the risk for heat illness (Montain et al 1994).

Psychological perceptions of comfort while exercising in moderate heat were not changed by the addition or total amount of fabric or the type of fabric worn (Gavin et al 2001). Additionally no significant differences in core body temperature were found

between three groups wearing either a polyester fabric geared towards aiding evaporation of sweat, exercising semi-nude, or wearing a cotton fabric.

HEAT ACCLIMITIZATION

A remaining factor in core body temperature regulation is the heat acclimatization of the athlete participating. Heat acclimatization, suggested by Yeargin et al (2006) can take 7-10 days before the athlete can increase intensity and duration during practice in high temperature environments. During proper acclimatization the core body temperature should not increase as high or as fast during exercise, allowing the athlete to exercise during higher temperatures before their core temperature reaches a critical level. In equine athletes, it was found that proper heat acclimatization, which in the study consisted of workouts in high heat and humidity for 21 days, was beneficial in avoiding uncompensable heat stress (Geor et al 2000).

Cheung and McLellan (1998) examined the effects of heat acclimation, physical fitness condition, and hydration on the tolerance of individuals to heat stress. These factors were chosen as the most influential in assessing the health risk for activity in a hot environment. Tolerance to the heat was found through increased fitness levels independent of how heat acclimated or how hydrated the participants were. Further noted was that with fluid replacement through water and other beverages, some increases in tolerance were found even in individuals who were not as physically fit. For football teams or other sports teams playing in extreme environments, hydration is an important factor in also decreasing the risk of succumbing to heat related illnesses (Cheung and McLellan 1998).

Geladas and Banister (1988) examined whether inhaling cold or hot air effected core body temperature and influenced athletes to continue exercising or terminate the activity sooner. Respiratory heat loss increased while respiratory rate, rectal temperature and heart rate all decreased significantly in the group inhaling cool (3.6°C) air compared to hot (control, ambient temperature) air while exercising. Participants inhaling cold air could be able to extend both the length and intensity of their exercise (Geladas and Banister 1988).

SUMMARY

Adequate hydration has been shown to be effective in maintaining exercise performance levels among athletes in the heat (Francis and Feinstein et al 1991). Athletes exercising in extreme heat are highly susceptible to losing high volumes of water through sweat. With fluid loss also comes electrolyte loss which can, among other things, impair performance and health. Therefore, it is recommended that athletes have access to a sports-drink to replenish those needs.

Athletes or those working in extreme temperatures are much more likely to handle heat and be more tolerant of extreme temperatures and weather when their face, hands, and neck are uncovered (Montain et al 1994). Because football players can't practice or play without helmets, and many use gloves, taking their helmets and gloves off as frequently as possible when off the field for breaks may be beneficial. Heat acclimatization of at least a week is an additional preventative method for decreasing heat illnesses (Cheung and McLellan 1998). While studies on hormonal effects were reviewed, their implication in our study or future studies, as well as the effect on our recommendations were less applicable as maintaining hydration, being heat acclimated

(at least 2 weeks of light activity in the heat before continuing on in conditioning), and being properly conditioned physically. Practical application for this information would again return to recommendations of proper hydration, prior physical conditioning, training of staff and medical personnel, and becoming acclimated to the heat prior to strenuous activity such as football practices and scrimmages.

APPENDIX C

BORG 15 POINT RATE OF PERCEIVED EXERTION SCALE

- 6 - 20% effort
- 7 - 30% effort - Very, very light (Rest)
- 8 - 40% effort
- 9 - 50% effort - Very light - gentle walking
- 10 - 55% effort
- 11 - 60% effort - Fairly light
- 12 - 65% effort
- 13 - 70% effort - Somewhat hard - steady pace
- 14 - 75% effort
- 15 - 80% effort - Hard
- 16 - 85% effort
- 17 - 90% effort - Very hard
- 18 - 95% effort
- 19 - 100% effort - Very, very hard
- 20 - Exhaustion

APPENDIX D

INSTITUTIONAL REVIEW BOARD SIGNATURE PAGE

Georgia Southern University Office of Research Services & Sponsored Programs	
Institutional Review Board (IRB)	
Phone: 912-681-5465	Administrative Annex P.O. Box 8005 Statesboro, GA 30460
Fax: 912-681-0719	Ovrsight@GeorgiaSouthern.edu

To: Dr. Jim McMillan
Dr. Stephen Rossi
P.O. Box-8076

From: Office of Research Services and Sponsored Programs
Administrative Support Office for Research Oversight Committees
(IACUC/IBC/IRB)

Date: July 18, 2007

Subject: Status of Application for Approval to Utilize Human Subjects in Research

After a review of your proposed research project numbered: H07252, and titled "The Effects of Shoulder Pad Cooling System on Core Body Temperature During College Football Scrimmage", it appears that (1) the research subjects are at minimal risk, (2) appropriate safeguards are planned, and (3) the research activities involve only procedures which are allowable.

Therefore, as authorized in the Federal Policy for the Protection of Human Subjects, I am pleased to notify you that the Institutional Review Board has approved your proposed research.

This IRB approval is in effect for one year from the date of this letter. If at the end of that time, there have been no changes to the research protocol; you may request an extension of the approval period for an additional year. In the interim, please provide the IRB with any information concerning any significant adverse event, whether or not it is believed to be related to the study, within five working days of the event. In addition, if a change or modification of the approved methodology becomes necessary, you must notify the IRB Coordinator prior to initiating any such changes or modifications. At that time, an amended application for IRB approval may be submitted. Upon completion of your data collection, you are required to complete a *Research Study Termination* form to notify the IRB Coordinator, so your file may be closed.

Sincerely,

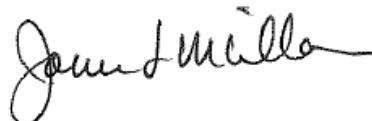


N. Scott Pierce
Director of Research Services and Sponsored Programs

4-25-08

As per email from Eleanor Hayes:

Kathryn Tice assisted Dr. McMillan and Dr. Rossi
with this research.



APPENDIX E

BIOGRAPHICAL SUMMARY

Kathryn Tice received her Bachelor's of Science degree from Bridgewater College, Bridgewater, Virginia in 2005 and will receive her Master's of Science degree from Georgia Southern University, Statesboro, Georgia in 2008. She plans to pursue doctoral studies in the near future and enjoys playing sports, going to the beach and riding her horses in her free time.