THE COLLEGIATE CROSS COUNTRY AND TRACK AND FIELD COACHES HEAT ACCLIMATION SURVEY

by

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ABSTRACT

Chronic exposure to heat can lead to heat acclimation (HA) and attenuate heat-related endurance performance decrements. In this study, a sample of 21 collegiate cross country and track and field coaches in the National Collegiate Athletic Association Division I (*n* = 14) and Division III (*n* = 7) completed a survey on the perceived value of HA as well as the HA methods used. Coaches use HA when preparing for hot-weather competitions but may be unaware of research on cool-weather performance benefits derived from HA. Most coaches (78.9%) utilize the natural environment for heat exposure during HA and use of excess clothing was also common (52.6%). Most coaches (63.2%) prescribe all intensities of exercise throughout HA. Overall, there was a lack of consistency among coaches on the value and the implementation of HA during training. This suggests a research-to-practice gap.

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Abbreviations

HA	Heat Acclimation
$VO_{2\ MAX}$	Maximal Oxygen Uptake
GAS	General Adaptation Syndrome
STHA	Short-Term Heat Acclimation
UCHS	Uncompensable Heat Stress
iEMG	Integrated Electromyography
MVC	Maximum Voluntary Contraction
HWI	Hot Water Immersion
NCAA	National Collegiate Athletic Association
SD	Standard Deviation

CHAPTER I

INTRODUCTION

Many of the world's largest sporting events take place during summer months when environmental conditions become major factors in performance. Without adequate preparations for hot and/or humid conditions, an athlete's performance can suffer. Given the high training loads required to maximize athletic performance, achieving heat acclimation (HA) in a way that is unobtrusive to normal training is of great interest to athletes and coaches in a high-performance context. While noting the various adaptations elicited from HA and the associated exercise performance improvements are valuable, understanding how high-level coaches and athletes put that knowledge into practice in real-world training scenarios can prove vital in directing future research in a more applied direction.

Research on HA has demonstrated that improvements in most of the factors that contribute to human thermoregulation take place in the first four to seven bouts of exercise in heat exposure (Périard et al., 2015; Shapiro et al., 1998). Improvements in factors such as plasma volume, sweat rate, core temperature, and maximal oxygen uptake ($VO_{2\ MAX}$) as a result of heat stress have coincided with increases in endurance performance in laboratory settings (James et al., 2017; Lorenzo et al., 2010). Lorenzo et al. (2010) found that cyclists who followed a 10-day HA protocol improved time trial performance 8% in hot conditions (38°C) and 5% in cool conditions (13°C). The significant performance improvements derived from HA demonstrated through research may provide sufficient evidence to coaches to give a level of confidence in prescribing

HA to their athletes. However, the way one implements a HA program that seamlessly fits into the broader context of high-level training is still unknown.

One limitation of much of the current HA research is the use of fixed work-rate exercise prescription throughout the HA protocol, which does not mirror training regimens utilized by high level athletes and coaches in the real world. For research purposes, individuals undergoing a HA protocol are often prescribed a consistent level of exercise throughout the entirety of the intervention, often measured by wattage or a percentage of $VO_{2\,MAX}$. Most high-level athletes favor a periodized training regimen that has been derived from the principles of general adaptation syndrome (GAS; Naclerio Ayllón et al., 2013; Selye, 1936). In a traditional periodized training regimen, athletes will undergo a high intensity training bout to generate an alarm response from the body. They then recover from that stimulus through a low-to-moderate intensity training bout, allowing for a supercompensation response and a progressed level of fitness (Naclerio Ayllón et al., 2013). How a HA protocol can interact with this cycle of varying training intensities has not been the subject of extensive research. Using a fixed work-rate protocol can lead to HA, but it does not allow for the requisite training stimulus and recovery period to increase overall athletic performance (Périard et al., 2015). Knowledge of how high-level coaches design a HA program that remains effective in conjunction with a contemporary training model will guide future sport-related HA research towards a more relevant, applicable direction.

The practical application of HA in a real-world sports performance context depends on the careful manipulation of key training variables. Research has described a variety of methods and modalities to achieve HA, but researched HA methodologies may not have high practical significance to athletes and coaches due to real-world limitations. The transfer of performance outcomes associated with HA protocols to real-world athletic success depends on the ability to implement these HA protocols in a real-world training regimen. With this in mind, a close examination of the modifiable variables associated with successful HA protocols and their real-world applicability is warranted. Coaches' opinions on the value of HA training in the performance context will also increase understanding of what role a HA program can play in an already dense high-level training program. Therefore, a survey of collegiate cross country and track and field coaches related to their design of heat acclimation protocols is necessary to guide future research.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Preparation for major sporting events occurring in hot or humid climates (e.g. 2021 Tokyo Olympics and 2022 FIFA World Cup in Qatar) is a foremost concern for athletes, coaches, and athletic trainers. In this review, a summary of the effects of high heat-stress on athletic performance and the human thermoregulatory adaptations derived from chronic heat exposure are presented. Strategies to elicit HA, including exercise-based short-term heat acclimation (STHA) interventions that may be particularly applicable to sport performance are then highlighted. The review ends with the proposition of a survey designed to investigate the real-world applicability of various HA protocols as used by sport coaches.

Heat Stress during Exercise

During endurance sport and exercise participation in hot and humid climates, the foremost concern in regarding athlete safety is elevated core temperature and the risk of heat illness. Physical exercise can increase metabolic heat production by 300% to 1,200% above resting rate, thus increasing the rate at which heat must be dissipated from the body (Parsons, 1993; Sawka et al., 2011). Sawka et al. (2011) stated heat stress comes from both metabolic and environmental (e.g. temperature, humidity, clothing, etc.) sources. Uncompensable heat stress (UCHS) occurs when the net heat stress is greater than the rate at which heat is dissipated from the body through normal thermoregulation. Under UCHS, core temperature will continually rise. The human body can generally maintain efficient thermoregulation throughout a core temperature range of 35°C - 40°C

(Parsons, 1993). However, pushing the upper bounds of this range has been shown to have a negative impact on exercise performance (González-Alonso et al., 1999; Nielsen et al., 1993).

González-Alonso et al. (1999) studied thermoregulation in cyclists by manipulating participants' initial core temperature and the rate of heat storage throughout a cycling trial at 60% $VO_{2\ MAX}$. In both the control and experimental environments, participants' esophageal temperature at exhaustion was measured to be 40.1 - 40.3°C, regardless of initial core temperature and the rate of heat storage (González-Alonso et al., 1999). In a similar study, Nielsen et al. (1993) had experimental participants exercise until volitional exercise termination in a 40°C environment for 9 - 12 consecutive days to induce HA. The cessation of exercise bouts each day coincided with participants' core temperature reaching a mean temperature of 39.7 ± 0.15°C, though the amount of time it took to reach that core temperature and coinciding exercise cessation increased after each subsequent day (Nielsen et al., 1993). These studies suggest that core temperature will rise until a critical point at which time athletic performance is compromised. Data from Nielsen et al. (1993) also supports that thermoregulation is a trainable factor that can influence exercise performance. Several key physiological responses to heat stress during exercise have been documented and are of particular interest when investigating adaptions to chronic heat exposure during exercise.

Impact of Heat on the Exercising Body

Body fluid volume and blood distribution

A primary concern regarding exercise performance in high heat stress conditions is that of sweat volume and body water loss. The secretion of sweat is the human body's method of thermoregulation through evaporation, but this can contribute to dehydration, which can have negative effects on health and performance (Cheuvront et al., 2013; Cramer & Jay, 2016). In many studies, high sweat rates are correlated with high heat and humidity, respectively (Galloway & Maughan, 1997; Sawka et al. 2007; Sawka et al., 2011). High sweat rates often lead to a significant decrease in blood plasma volume, a factor that ultimately decreases stroke volume. An increase in heart rate, termed by Rowell (1974) as cardiac drift, must compensate for the decrease in stroke volume to maintain exercising cardiac output in the heat. As athletes reach maximal effort, heart rate can no longer increase to maintain cardiac output, thus allowing heat and the coinciding plasma volume decrease to compromise athletic performance (Rowell, 1974).

While changes in total plasma volume due to heat can affect exercise, changes in the distribution of blood throughout the body as a thermoregulatory response also create performance limitations. During exercise in the heat, blood is shunted closer to the skin surface and away from the working muscles in order to dissipate body heat via convective currents at the periphery (Galloway & Maughan, 1997; James et al., 2017; Rowell, 1974). As blood volume distribution shifts to cutaneous and subcutaneous tissue, the capacity for oxygen transportation to the working muscles decreases, which is a detriment to exercise performance (Galloway & Maughan, 1997; James et al., 2017; Rowell, 1974). In addition to a decreased supply of oxygen, the exercising muscles may also experience central limitations under high heat stress conditions through decreases in neuromuscular activity.

Neuromuscular response

There is evidence that UCHS decreases neuromuscular recruitment (Nybo & Nielsen, 2001; Thomas et al., 2006; Tucker et al., 2004). Tucker et al. (2004) had participants perform a self-paced 20-kilometer cycling time trial in both cool (15°C) and hot (35°C) environments. Core temperature, power output, and the integrated electromyographic (iEMG) data of the vastus lateralis were recorded. Despite a lack of deviation in core temperature between participant groups, the participants in the hot conditions displayed significantly lower muscle activity and power output, beginning as early as 30% into the time-trial (Tucker et al., 2004). Tucker et al. (2004) suggested the brain may reduce muscle activation early in an exercise bout in the heat as an anticipatory measure. Nybo and Nielsen (2001) demonstrated that muscle activity during a sustained maximal voluntary contraction (MVC) in a hot environment declines at a faster rate than in a cool environment. This decrease is present despite no apparent decrease in maximal force via electrical stimulation. The researchers concluded that impaired muscular performance was due to a decrease in voluntary activation (Nybo & Nielsen, 2001). In research by Thomas et al. (2006), participants' core temperatures were passively raised to 39.5°C using a water-heated garment while one leg remained uncovered in a normothermic environment. A significant decrease in maximal voluntary activation and maximal torque of the plantar flexors occurred in the hyperthermic appendage and the contralateral, normothermic appendage (Thomas et al., 2006). This further indicates decreased neuromuscular recruitment during UCHS is a result of a central limitation due to increased core temperature rather than being localized to the activated muscle.

One alternative explanation for the resultant decrease in neuromuscular activity during high-heat exercise is that heat may impair the mechanical process of action potential transmission. However, research from Rutkove et al. (1997) demonstrated action potential velocities increase as temperature increases and effective conduction blocks likely do not occur until temperatures between 44 and 48°C. Thus, the temperatures that prove detrimental to the action potential process were not reached during prior studies on the neuromuscular activity in high-heat conditions (Nybo & Nielsen, 2001; Thomas et al., 2006; Tucker et al. 2004). This lends credence to the notion that decreases in neuromuscular activity are due to a central limitation rather than a mechanical limitation. Given the suggested anticipatory nature of this decrease in neuromuscular activation, one could presume that increased conditioning and training in hot environments could decrease this effect.

The multitude of physiological responses associated with acute heat stress can have a negative impact on exercise performance. Individuals performing exercise in high heat may experience limitations not only from changes in the oxygen transportation capacity, but from anticipatory central limitations. However, many of these physiological responses are adaptable in response to the stimulus of chronic heat exposure, leading to a greater thermoregulatory capacity.

Human Adaptations to Chronic Heat Stress

The human body undergoes several adaptations following chronic heat stress during exercise. One of the primary adaptations is a lower core body temperature at the same relative work rate in subsequent exposures (Périard et al., 2015; Racinais et al., 2015; Sawka et al., 2011). James et al. (2017) measured heat adaptation and performance factors before and after a five-day STHA protocol. Participants who underwent STHA had a reduced core temperature following a 5-kilometer time trial relative to their pre-intervention values (James et al., 2017). Other studies found similar reductions in core temperatures following STHA (Fein et al., 1975; Lorenzo et al., 2010; Shin et al., 2013). An increase in the core-skin temperature gradient and a decrease in skin temperature following STHA have also been demonstrated, thus increasing the body's cooling potential through conduction (Cramer & Jay, 2016; Lorenzo et al., 2010). The reduction in core temperature is attributed to a multitude of central and peripheral adaptations.

The sweat response

Sawka and Coyle (1999) highlighted multiple thermoregulatory adaptations following heat exposure including increased sweat rate, decreased time to sweat onset, and decreased sodium loss through sweat. Nadel et al. (1974) demonstrated that participants who completed a 10-day STHA protocol had an increased sweat rate and sweat responsiveness. In a meta-analysis of 96 articles related to HA protocols, a mean decrease of core temperature at sweat onset during exercise of 0.28 ± 0.21°C following HA was documented (Tyler et al., 2016). Providing an adequate water vapor pressure gradient in the surrounding environment exists, this increase in sweat rate relates to an increase in the body's ability to dissipate heat through evaporation (Cheung, 2010).

A notable adaptation to chronic heat stress is the decrease in sodium concentration of sweat (Bates & Miller, 2008; Kirby & Convertino, 1986; Tyler et al., 2016). Through seasonal acclimatization, individuals sweat more yet lose less sodium through sweat during exercise in summer months compared to winter months (Bates & Miller, 2008). Using the ratio of sweat sodium reabsorbed to plasma aldosterone levels, Kirby and

Convertino (1986) demonstrated that an exercise-based STHA protocol increased sweat gland responsiveness to aldosterone, ultimately attenuating sodium loss through sweat. By preserving sodium, an acclimated body would be able to better maintain the osmotic pressure of extracellular fluid (Kirby & Convertino, 1986). Coinciding with the adaptations to sweat response are adaptations to total body fluid volumes in response to chronic heat stress.

Changes in plasma volume

Sawka and Coyle (1999) highlighted an increased plasma volume and increased total body water in the human body in response to chronic heat stress. In one of the earliest studies to quantify increases in blood plasma from heat stress, King et al. (1985) found that participants displayed a mean plasma increase of 9.2% following an eight-day STHA protocol. Lorenzo et al. (2010) also found increases in blood plasma volume (6.5 ± 1.5%) following a 10-day HA protocol. In the aforementioned study, pre-acclimation plasma volume was calculated using an equation adapted from Sawka et al. (1992) and post-acclimation changes were quantified from a technique utilizing hematocrit and hemoglobin changes created by Dill and Costill (1974).

Lorenzo et al. (2010) correlated an increase in cardiac output and $VO_{2\ MAX}$ in both hot and cool environments following STHA to the increase in blood plasma. In this study, participants performed $VO_{2\ MAX}$ tests and cycling time trials in both hot (38°C) and cool (13°C) conditions before and after a 10-day HA protocol. Relative to pre-intervention time trial values, the STHA increased maximal cardiac by 9.1 ± 3.4% in cool conditions and 4.5 ± 4.6% in hot conditions during the post-intervention time trial (Lorenzo et al., 2010). The increase in cardiac output corresponded with a post-STHA

$VO_{2\ MAX}$ increase of 5% in cool conditions and 8% in hot conditions (Lorenzo et al., 2010). James et al. (2017) also demonstrated an increase of $VO_{2\ MAX}$ in hot and humid conditions (32°C and 60% relative humidity). These improvements followed a 5-day STHA intervention that prescribed a daily 90-minute cycling bout in warm conditions (36°C and 59% relative humidity). These demonstrated increases to plasma volume following HA could influence maximal cardiac output, thus allowing greater oxygen delivery capacity to the working muscles. In addition to improvements in oxygen delivery, chronic heat exposure may allow for metabolic and neuromuscular adaptations.

Metabolic response

An additional adaptation is an increase in total work output at the metabolic and neuromuscular levels (Périard et al., 2015). To study the effects of STHA on sprint and submaximal exercise performance, King et al. (1985) had participants perform a single cycling exercise bout that began with a 45-second maximal effort sprint, followed by six hours at a submaximal (50% $VO_{2\ MAX}$) effort, and finished with another 45-second maximal effort sprint. Participants then completed an eight-day STHA protocol. Compared to pretest values, there was a 42% reduction in muscle glycogen usage during the submaximal exercise. This decrease in muscle glycogen usage could have profound impacts on performance in endurance sports where total glycogen use can be a limiting factor such as long-distance cycling or marathon running. King et al. (1985) also found a decrease in blood lactate concentrations following the initial sprint and an increase in sprint performance following the six-hour submaximal bout. Mirroring the findings of King et al. (1985), Lorenzo et al. (2010) demonstrated a 5% increase in participants' lactate threshold following a STHA intervention. Lorenzo et al. (2010) utilized a 10-day acclimation protocol that included 90 total minutes of cycling at 50% $VO_{2\ MAX}$ each day. The increase in lactate threshold was demonstrated in both warm (38°C) and cool (13°C) environments, suggesting the thermoregulatory and performance related adaptations may impact cool weather performance as well as hot weather performance (Lorenzo et al., 2010).

Adaptations to chronic heat exposure such as improved sweat response, increased plasma volumes, and altered metabolic and neuromuscular function have favorable thermoregulatory outcomes. However, effectively generating these adaptations such that performance is also improved is vital in a sporting context.

Improving Exercise Performance with Heat Acclimation Protocols

Heat acclimation and performance results

With the profound physiological effects demonstrated by researchers, a foremost concern for athletes, coaches, and trainers centers around whether or not a given HA protocol will improve performance. James et al. (2017) found amateur runners who completed a five-day STHA protocol had a mean improvement of 6.5% in 5-kilometer time trial performance in a hot environment, which significantly differed from those in the control group who did not undergo a STHA. The study performed by Lorenzo et al. (2010) was one of the first to demonstrate a significant improvement in time trial performance in both cool and hot environments following a STHA protocol. While these performance improvements have been demonstrated in a research environment, the practical significance of these results are dependent on whether a variety of researched HA protocol variables can be effectively utilized in coaches in athletes outside of the laboratory. The primary concerns associated with creating an effective HA protocol that will improve athletic performance involves the careful manipulation of the intensity of exercise, volume and density of heat exposures, and environmental conditions of said exposures.

Exercise intensity

Researchers have concluded that different exercise intensities can elicit similar HA responses (Houmard et al., 1990; Racinais et al., 2015). Houmard et al. (1990) demonstrated this by comparing the HA responses gained by two separate nine-day STHA protocols to a control. Participants in the first intervention group who exercised at 50% $VO_{2\ MAX}$ for 60 minutes per day displayed similar levels of HA as the second group, who exercised at 75% of their $VO_{2\ MAX}$ for 30 to 35 minutes per day (Houmard et al., 1990). This study, as well as the majority of STHA research, utilized constant work rate STHA protocols, i.e. each exercise bout in a protocol is prescribed at the same metabolic workload, usually measured by a percentage of an individual's $VO_{2\ MAX}$. This means that as HA takes place throughout the protocol, relative intensity decreases (Racinais et al., 2015). Researchers have argued that because a constant work rate HA protocol will elicit a gradually decreasing training stimulus, exercise intensity prescription based on a controlled heart rate would be favorable (Périard et al., 2015; Racinais et al., 2015; Taylor & Cotter, 2006). Utilizing a heart rate monitor and set training zones based on heart rate during a STHA intervention would allow for a relative intensity to remain constant throughout the intervention, even as HA begins to occur.

Volume and density of exposures

Most physiological adaptations to heat stress occur in the first four to seven days of exposure, and further adaptations wane after a 14-day exposure period (Garrett et al., 2011; Périard et al., 2015; Shapiro et al., 1998). In a consensus piece on STHA protocols for athletes, Racinais et al. (2015) recommended a HA protocol to last about two weeks to capitalize on the full acclimation period. However, many researchers have used protocols with an eight to ten-day intervention period (King et al., 1985; Lorenzo et al., 2010). In a systematic review of prior HA research, Garrett et al. (2011) classify HA protocols into three categories based on number of heat exposures, short-term HA (< 7 days), moderate-term HA (7 - 14 days), and long-term HA (≥ 15 days). Garrett et al. (2011) concluded that prior the body of HA research supports the use of 5-day STHA protocols for moderately-to-highly trained athletes as this volume of exposures is enough to generate the requisite thermoregulatory adaptations without sacrificing a longer training cycle. Similarly, a meta-analysis of HA research from Chalmers et al. (2014) found significant performance improvements in as little as five days of heat exposure during exercise, given the exposures were of at least 60 minutes and exercise intensity was high.

Though many researchers have focused on using consecutive-day HA protocols, Fein et al. (1975) demonstrated that similar levels of HA were acquired between participants who had daily heat exposure versus participants who had intermittent (every third-day) heat exposure given that the total amount of heat exposures were the same. Willmott et al. (2016) suggested that more rapid HA can occur through twice-daily heat exposure, though the effects from their experimental and control STHA protocols were small.

While complete acclimation through a multi-week HA intervention could elicit comprehensive thermoregulatory adaptations, the extended interruption to normal training loads may ultimately sacrifice overall performance. HA strategies suggested by Garrett et al. (2011) and Chalmers et al. (2014) show promise that STHA interventions using as few as 5 exposures can balance both thermoregulatory and performance benefits. Further research has demonstrated that 5 exposures can elicit the desired exercise performance benefits in hot environments (James et al., 2017). Finding an optimal balance between time spent under heat stress to generate HA with time spent training in adequate normothermic conditions foundational variable when designing a HA protocol. Understanding the total number of exposures typically used in HA programs designed by high-level coaches will give researchers a better grasp of the practical limitations of HA protocol in a real-world training environment.

Environmental conditions

Consensus recommendations for athletes preparing for hot weather competitions suggest utilizing a heat acclimation intervention that prescribes training conditions that closely mimic the expected performance conditions closely (Périard et al., 2015; Pryor et al., 2019; Racinais et al., 2015). However, many athletes do not have access to natural locales that perfectly mimic performance conditions. The use of climate-controlled chambers to generate a thermal stimulus for individuals undergoing heat acclimation is often used in performance and research settings as the natural environment is difficult to control for in an acclimatization protocol.

Much of the research surrounding HA and the consensus recommendations for STHA protocols for athletes prescribe the use of climactic chambers that rely on warmed air to generate hyperthermia in the human body (Casadio at al., 2017; Racinais et al., 2015). Given that a climactic chamber is an inaccessible tool to many athletes, other methods to generate UCHS during exercise are warranted. The use of hot water immersion (HWI) in a STHA intervention could not only be a surrogate for a climactic chamber, but also could be more advantageous due to the thermal properties of water. Because the thermal conductivity of water is 27 times that of air, immersion in hot water provides a higher thermal load on the human body compared to air at a similar temperature (Cheung, 2010). Research has supported the notion that water is a not only a highly effective medium for generating positive thermoregulatory adaptations, but can be used to rapidly generate these adaptations as well (Brazaitis & Skurvydas, 2010; Shin et al., 2013; Zurawlew et al., 2018; Zurawlew et al., 2016).

Recent research has demonstrated that STHA protocols utilizing passive HWI have elicited noticeable positive thermoregulatory and exercise performance related adaptations using exposures of 40 minutes or less (Shin et al., 2013; Zurawlew et al., 2018; Zurawlew et al., 2016). This suggests that using water as a medium to transfer heat into the human body and generate hyperthermia could be effective during the HA process without interrupting regular training session intensity.

Prior research has included a multitude of exercise intensities, conditions, and exposure schedules to elicit heat acclimation. While a long-term approach to heat acclimation may generate full acclimation, the gains in thermoregulatory capacity may be outweighed by interruptions to normal training when athletic performance is considered. Utilizing a protocol that can rapidly generate high-magnitude thermoregulatory adaptations without creating major interruptions to a training schedule would be a major benefit to an athlete.

Real-World Application

One of the primary roles of a sports coach is to maximize the performance of athletes under his or her care. When research provides a multitude of variables to consider when designing a HA protocol, a coach must weigh what will ultimately maximize performance and work within the constraints of the overall training program. Much of the research in HA protocols may not be applicable to most coaches, whether through lack of expensive laboratory equipment like environmental chambers, or because of a lack of research into how HA protocols can fit into an already dense training schedule.

A limitation in most HA research to this point is that constant work rate protocols included in many studies do not mirror a real-world athletic training program. The majority of athletes on all levels utilize a periodized training schedule based on the principles of Selye's (1936) proposed GAS in order to maximize athletic performance (Naclerio Ayllón et al., 2013). In a traditional periodized training regimen, high-intensity exercise bouts are prescribed to generate an alarm phase in the body (Naclerio Ayllón et al., 2013). Appropriate recovery following this alarm stimulus allows for a supercompensation response and a progressed level of fitness (Naclerio Ayllón et al., 2013). Because high intensity exercise in the heat is hard to maintain, there could be a decreased training stimulus for each exercise bout during a STHA protocol that ultimately detracts from maximal performance. (Taylor & Cotter 2006). For example, the aforementioned study by James et al. (2017) found that time to exhaustion was reached 19% faster during a single $VO_{2\,MAX}$ bout in the heat compared to ideal conditions. This decrease in aerobic performance in the heat may potentially diminish the aerobic stimulus in a single training bout (Sawka et al., 2011). The use of STHA protocols may further compromise neuromuscular training stimuli due to the reduction in neuromuscular recruitment demonstrated by prior research (Nybo & Nielsen, 2001; Tucker et al., 2004). The decrease in overall performance when exercising in the heat could have the largest compromising effect during high intensity training bouts designed to create a large enough alarm in the body to generate fitness adaptations.

As coaches implement their own HA programs with their athletes, they gain unique insight into what may or may not work within the constraints of real-world training. The knowledge coaches have gained in the applicability of HA protocols in conjunction with high-level training can serve as a compass for future studies with the goal of maximizing sport performance within real-world constraints. Therefore, a survey of current high-level sport coaches on the topic of HA protocols that have real-world applicability will provide guidance for future HA research.

Conclusion

A variety of HA protocols in the laboratory setting demonstrate clear improvements in a multitude of human performance factors compared to baseline levels (Garrett et al. 2011; Périard et al., 2015; Racinais et al., 2015). However, due to the acute decrease in exercise performance in the heat, there may be a relevant decrease in training stimulus from many HA protocols that could lead to a net decrease in overall sport performance despite improving many HA factors. As the main goal of exercise and athletic training programs in competitive settings is to maximize performance, future research can be directed towards the effective and practical applications of HA strategies within a realistic high-level athletic training program in order to maximize performance.

Therefore, a survey of coaches of high-level endurance athletes on the characteristics of HA programs they have successfully utilized in the past could bridge a gap between environmental physiology research and real-world application. Gaining insight into real-world HA protocols in terms of number of heat exposures, the duration of individual heat exposures, intensity exercise, and methods of generating heat will be valuable in assigning characteristics to HA in future research. Knowledge gained about the real-world application of HA protocols will help guide future research by understanding the limitations coaches face when designing a HA protocol and the practicality of many oft researched strategies.

CHAPTER III

METHODOLOGY

Participants

National Collegiate Athletic Association (NCAA) division I and III Cross Country and Track and Field coaches (N = 20) specializing in coaching distance runners participated in this survey. The sample included head and assistant coaches of mens' and womens' teams. The institutional review board at Middle Tennessee State University approved all methods and procedures utilized in the study (see Appendix A). Participants provided consent by answering in the affirmative to an informed consent question (see Appendix B) to begin the online survey.

Survey

A survey of HA strategies utilized by collegiate cross country and track and field coaches (see Appendix C) was developed and administered using the Qualtrics online survey platform (Qualtrics XM, Provo, Utah, USA). Prior to dissemination, survey questions were reviewed for readability and clarity by co-investigators and select cross country and track and field coaches. Changes to survey content and language were made to improve survey quality based on these reviews.

The 16-question survey consisted of three sections. The first section included seven demographic questions on years of experience, level of education, coaching role (assistant or head coach), sex of the athletes coached, geographic location of the school coached, status of participation in recent national championship events, and NCAA division. The second section contained four Likert questions designed to gauge coaches' perceived importance of HA protocols and determine real-world viability. The third section contained five questions where coaches were asked to select and describe characteristics of HA protocols they have utilized successfully. The characteristics of HA protocols were organized by four variables supported in HA literature: number of exposures, method of heat transference, intensity of exercise during heat exposure bouts, and number of days prior to peak performance that a HA protocol was initiated (Casadio et al., 2017; Chalmers at al., 2014; Garrett et al., 2011; Houmard et al., 1990; Pryor et al., 2019)

Procedures

Survey participants were recruited Summer 2020 through convenience sampling, word of mouth, and ads posted on the message board of LetsRun.com. Coaches of mens' and womens' teams that qualified for the 2019 NCAA Division I, II, or III Cross Country National Championships were recruited for participation in this study. An email (see Appendix D) containing a brief introductory message and a link to the survey hosted by Qualtrics was sent to the publicly available email addresses of these coaches posted on their respective colleges' athletics websites. Additionally, a message containing a brief introduction and a link to the survey hosted on Qualtrics was posted on the message board for LetsRun.com, a highly trafficked website with content focused on distance running. In each introductory message, potential participants were asked to refrain from completing the survey multiple times to avoid duplicate responses. Potential participants were given a 14-day window to complete the survey from the day of survey dissemination. An email reminder to complete the survey was sent on the 7th day following survey dissemination to each potential participant. The same reminder was posted on the LetsRun.com message board on the 7th day following survey dissemination.

Collection of survey responses was ceased following the 14th day after survey dissemination.

Data Analysis

Survey responses were analyzed for the descriptive statistics mean and mode for numerical responses and frequencies for categorical responses. A Chi-square test of independence was run among demographic responses and HA protocol characteristic responses. All statistical procedures were completed using IBM SPSS Statistics for Windows (IBM SPSS Statistics, Version 24.0; IBM Corp., Armonk, NY, US)

CHAPTER IV

RESULTS

Participants

A sample of 21 coaches completed all or part of the Collegiate Cross Country and Track and Field Coaches Heat Acclimation survey. Demographic characteristics of participants (*N* = 21) coaches are reported in Table 1.

Participants were evenly distributed by location relative to climate. Participants were divided by those who coached in states above the midpoint of latitude for the contiguous United Sates (39°50'N) or above an average elevation of 1,500m (*n* = 11) and those who coached in states below the midpoint latitude and below an elevation of 1,500m (*n* = 10). The sample included participants who coached both males and females (*n* = 17), and participants that only coach mens' (*n* = 2) or womens' (*n* = 2) teams. The sample included coaches of national championship qualifying teams within the last 5 years (*n* = 17), with the rest having not recently coached at that level. The level of coaching experience of participants is reported in Table 2.

Perceived Value of Heat Acclimation

Participant responses to perceived HA value questions are reported in Table 3.

Heat Acclimation Intervention Characteristics

Participants (*n* = 19) selected descriptors for characteristics of HA programs they have utilized successfully. Of the 21 coaches who began the survey, 19 completed this 5-question section. Participants were allowed to select multiple options for each question in this section. When prescribing a HA program, 52.6% of the respondents utilize between 7 and 14 heat exposures, 36.9% use less than 7 heat exposures, and 10.5% use more than

Table 1

Demographic Characteristics of Coaches

		Participants
Level of Collegiate Athletics	Division I	14
	Division III	7
Coaching Role	Head Coach	14
	Assistant Coach	7
Highest Level of Education	Bachelor’s Degree	7
	Master’s Degree	13
	Doctorate Degree	1

Table 2

Years of Coaching Experience

Experience	Number of Coaches
0 – 9 Years	5
10 – 19 Years	8
20 – 29 Years	1
30 or More Years	7

Table 3

Opinions on HA Value

	Question			
	I prescribe HA for performance in hot conditions	I prescribe HA for performance in all conditions	I have adequate resources to prescribe an optimal HA intervention	My athletes can maintain an appropriate training intensity while undergoing HA
Number of responses	19	21	21	21
Likert response (Mean ± SD)	3.4 ± 1.0	2.6 ± 1.2	3.2 ± 1.1	3.0 ± 1.0

Note. Numerical values from 1 to 5 were assigned to a level of agreement along a Likert scale for questions of heat acclimation (HA) value, with 1 representing the least agreement, 5 representing the most agreement, and 3 representing neutral.

14 exposures. To describe the preferred timing and structure of a preferred HA program, coaches reported the number of days prior to peak competition they would begin an HA program. The responses are depicted in Figure 1. Of the coaches that selected "Other" as an option, one coach added that the bulk of HA training came in the pre-season, but additional heat exposures would be prescribed periodically as peak competition drew near. The other coach stated that due to being in the south, timing is informal and can utilize weather whenever it occurs.

Coaches' preferred exercise intensity prescription during heat exposure is depicted in Figure 2. Both coaches that selected high-intensity exercise as the preferred heat exposure intensity added that high-intensity intervals with low repetition volume and extended recovery periods that are preferred.

The preferred duration of bouts of heat exposure is depicted in Figure 3.

Preferred methods of heat exposure were selected by participants. These methodologies are depicted in Figure 4. Both coaches that selected "Other" described the use of indoor exercise in a warm room akin to a climactic chamber, though not in an environment specifically designed for controlled environmental conditions.

Chi-Square Test of Independence

The location of the school that participants coached at was associated several HA protocol characteristics as well as specific HA protocol opinions. Coaching location was divided into 2 groups, those who coach in northern (above 39°50'N) or high-altitude (states with an average elevation above 1,500m) states and those who coach in southern (below 39°50'N) and low-altitude (states with an average elevation below 1,500m) states.

Figure 1

Timing of Heat Acclimation Programs

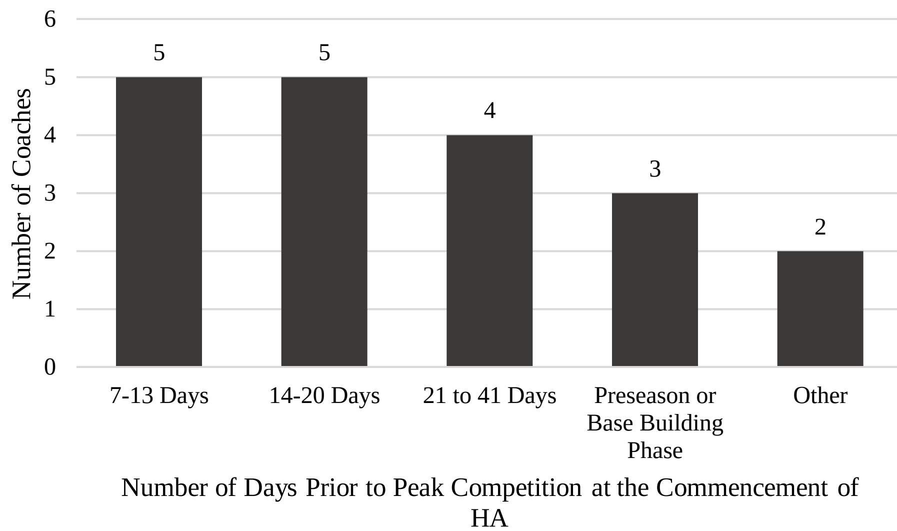
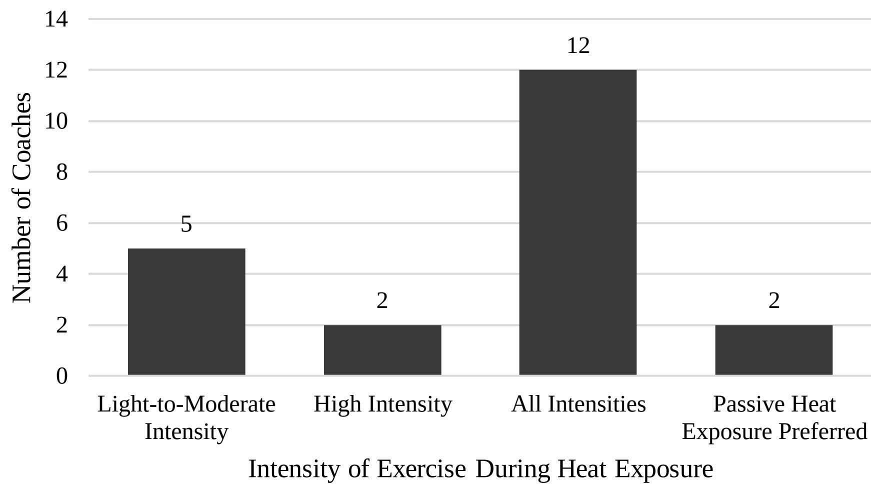


Figure 2

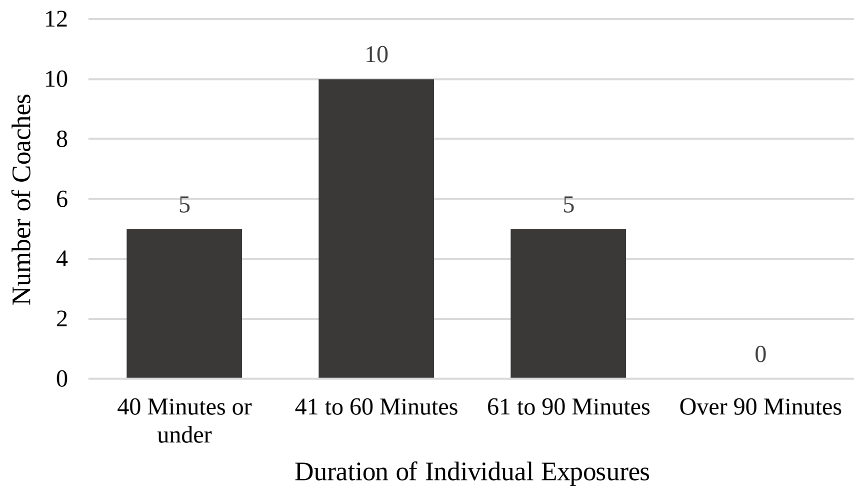
Preferred Exercise Intensity During Heat Exposure



Note. As coaches could select multiple satisfactory options, a total of 21 selections were made by 19 participants.

Figure 3

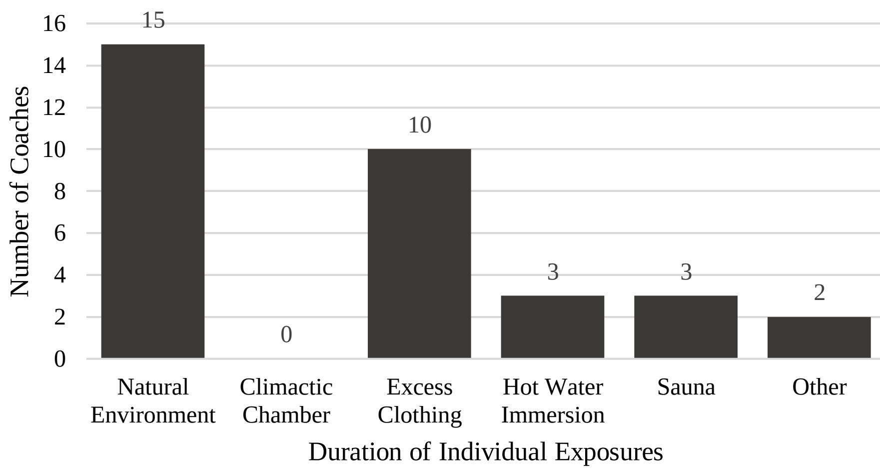
Duration of Individual Heat Exposures



Note. A total of 20 selections were made by 19 participants.

Figure 4

Preferred Heat Exposure Methods



Note. A total of 33 selections were made by 19 participants.

A chi-square test of independence was run to examine the relationship between the use of the natural environment as a heat exposure method and the location of the participant. The relation between these variables was significant, X^2 (1, N = 19) = 4.6, p = .033. Coaches in southern states utilize the natural environment at a much higher rate than coaches in northern or high-altitude states. Coaches in northern or high-altitude states trended towards using excess clothing as a heat exposure method compared to those in southern states X^2 (1, N = 19) = 2.6, p = .110. A chi-square test of independence was run to examine the relationship between coaching location and self-reported confidence in the availability of resources to prescribe an effective HA program. The relation between these variables was significant, X^2 (3, N = 19) = 11.6, p = .009. Coaches in southern states recorded higher levels of confidence in the availability of resources to prescribe an effective HA protocol compared to those in northern or high-altitude states.

Chi-square tests of independence were run to examine the relationship between the level of education coaches possess with a multitude of HA protocol characteristics. Coaches' education had significant relation with the use of HWI, X^2 (2, N = 19) = 6.3, p = .043. Coaches with higher levels of education were more likely to use HWI as a heat exposure method in a HA program. There was also a significant relationship between education and the frequency that a coach would prescribe HA programs for performance in all conditions X^2 (8, N = 19) = 25.1, p = .002. Coaches with higher education prescribed HA programs to improve performance in all weather conditions more frequently than those with less education. No other significant relationships among demographic responses, perceived HA value, and HA characteristics were demonstrated.

CHAPTER V

DISCUSSION

This study examined the real-world use and prescription of HA interventions by coaches of high-level endurance athletes. This was accomplished by surveying collegiate cross country and track and field coaches (*N* = 21) on their perceived value of HA interventions as a means to improve athletic performance and the characteristics of HA programs that they prescribe to their athletes. Perceived value of HA was assed via four questions scored on a 5-point Likert scale.

Despite a few key trends, there was a lack of consensus towards the value of utilizing HA to improve athletic performance. While the average response to each question neared a neutral response, there was a high degree of variability in responses for each question, as demonstrated by the high standard deviations (SD). This indicates a wide range of opinions among the coaches sampled on the value of HA. On questions of the frequency at which they prescribed HA, coaches were given the options of "never," "rarely," "sometimes," "often," or "always." On average, coaches responded that they prescribed HA to improve performance in hot conditions at a frequency between "sometimes" and "often", a mean value of 3.4 out of 5 on the Likert scale. Of those that responded to this question, 47.4% responded that they would "sometimes" prescribe HA, 21.1% responded that they would "often" prescribe HA, and 15.8% would "always" prescribe HA. This indicates that several of the coaches are aware of the performance benefits HA can elicit in endurance athletes highlighted by previous research and consensus opinion (James et al., 2017; Périard, et al., 2015; Racinais et al., 2015; Sawka et al., 2011). However, the existent variability (*SD* = 1.0) among coaches sampled demonstrates there is still a lack of consensus on the extent of the value of HA in an elite training program. This lack of consensus may be due to coaches that may be unaware of the research, or may be aware, yet have unknown reasons for why they choose not to prescribe HA. Follow up studies should be conducted to investigate the primary limiting factors for coaches of collegiate endurance athletes not utilizing this technique in preparing athletes for competition. Additional studies should evaluate the quality of continuing education of high-level coaches and investigate the ability of coaches to stay informed through access to current research.

On average, coaches responded that they prescribe HA with the goal of improving performance in all conditions at a frequency between “rarely” and “sometimes,” a mean value of 2.6 out of 5 on the Likert scale. While the majority of coaches responded that they would “rarely” (33.3%) or “never” (19.0%) prescribe HA to improve performance in all conditions, 19.0% of those that responded replied that they would “often” prescribe HA for this purpose and 4.8% responded that they would “always” prescribe HA. This suggests that while most coaches that prescribe HA programs do so with the primary focus on performance in hot conditions, some coaches do ascribe to the notion that HA related adaptions can improve performance in all weather conditions. A Chi-Square test for independence indicated coaches with higher levels of education more frequently prescribed HA for performance improvements in all weather conditions. This may mean that coaches with higher levels of education are more likely to stay up to date with current research, such as that from Lorenzo et al. (2010) who suggested cool-weather performance improvements from HA. Despite the limited number of coaches that utilize HA for all-condition performance, the few that do and the high level of education that is associated with those coaches suggests that it is not an idea that is dismissed outright. Because research on HA improving cool weather performance is still novel, it would likely take follow up studies to Lorenzo et al. (2010) that indicate similar findings before more coaches adopt the universal use of HA for all weather performance improvement. Studies examining cool weather performance following HA that utilize large sample sizes and a variety of training intensities and modalities would provide more insight to coaches.

Coaches surveyed displayed a lack of consensus in the confidence that their athletes could achieve the requisite training intensity during HA, again as evidenced by the variability (*SD* = 1.0) in the corresponding survey question. Many (38.1%) of the coaches responded that they “agree” to the statement that their athletes could maintain an appropriate training intensity while undergoing HA, however 28.6% “disagreed” with this statement and 4.8% “strongly disagreed” with this statement. Optimizing the training stimulus while undergoing HA has previously been highlighted by researchers as an area for further study (Casadio et al., 2017; Stevens, 2018). A lack of consistent opinion among coaches in regard to whether or not undergoing HA would negatively impact their athletes’ training stimulus further suggests a need for research investigating the broader impact of HA on training. Research utilizing methodologies specifically designed to evaluate real-world training stimulus during heat exposure and its ultimate effects on race-day performance would be helpful to coaches and researchers alike. Research using metrics to evaluate total strain and recovery throughout a training cycle while undergoing HA may give insight to the impact of heat exposure on overall training stimulus. A calculation of training impulse often utilized in previous research may be a guide in understanding the total strain on an athlete during HA and provide direction to coaches on whether or not HA will negatively impact training (Banister & Calvert, 1980).

The common theme regarding the responses to the Likert scale questions was a lack of consensus among coaches. It is possible that some coaches may be aware of research supporting the use of HA to improve athletic performance and still choose not to employ HA. However, it is more likely that information regarding the effectiveness of HA and strategies to optimize HA during training has not been disseminated to coaches effectively. A prior survey of 222 elite coaches from 19 different sports indicated that current methods of disseminating research findings to coaches is ineffective, leading to a research-to-practice gap (Williams & Kendall, 2007). It was posed that more effective strategies to circulate new research findings included the use of trade magazines, online coaching forums, and continuing-education courses for coaches. Coaches highlighted the lack of "lay" language in academic research as a reason for the knowledge gap between researchers and coaches (Williams & Kendall, 2007). Results of the present survey suggest, in concordance with the prior research, current strategies for disseminating new information from academic research to coaches is still ineffective. While there is clear evidence that HA is an effective tool to be used for performance benefit, there are coaches who still do not employ this training strategy. Knowledge gained by researchers through academic research is most valuable to coaches when it can effectively be circulated. New strategies for knowledge transfer between researchers and coaches is pertinent. Research has highlighted the need for educational strategies that emphasize personal interaction between researchers and coaches as a tool to optimize knowledge transfer (Fullager et al., 2019). One potentially effective strategy to encourage this researcher-practitioner interaction would be through continuing education seminars and courses for coaches hosted through a combined effort from sport governing bodies and academic journals. With greater interaction between researchers and coaches, many coaches would be better equipped with up to date, evidenced based training guidelines and strategies.

Among the other key findings of this survey were coaches' preferred HA protocol characteristics. The 89.5% of coaches preferred utilizing fewer than the 14 exposures that prior research suggests elicits full acclimation (Garrett et al., 2011; Périard et al., 2015; Shapiro et al. 1998). Coaches may eschew full acclimation for the preservation of regular training prior to competition allowed by a shorter HA period. This is valuable as both Chalmers at al. (2014) and Garrett et al. (2011) indicated that significant performance increases can occur via STHA programs and 5 heat exposures may be ideal to maximize performance.

Coaches generally preferred using multiple exercise intensities during heat exposure with 63.2% of the coaches responding that they use all training intensities during a HA program. As Houmard et al. (1990) demonstrated that a variety of training intensities during heat exposure can elicit HA, coaches using all training intensities is likely sufficient to induce HA. However, little research has investigated what training intensities during a HA program ultimately maximizes performance. Of note were the two coaches who specifically mentioned using low-volume high-intensity interval training with high rest volumes as the training stimulus during HA. This could be a particularly effective method to generate the requisite thermal stimulus required to induce HA while preserving a high-level training stimulus. Low enough repetition volumes may avoid central fatigue that appears during longer exercise bouts and may be anticipatory in nature (Tucker et al., 2004). The variety of responses from coaches and lack of research into the effect of training intensities during HA on athletic performance leads to a specific question: When aiming for maximized athletic performance, is it preferable to utilize heat exposures on easy or recovery days to preserve the training stimulus on high intensity days, or is it preferable to gain the specific stimulus of high-intensity heat exposures?

Only 10.5% of coaches stated that they make use of passive exposure during HA. This is also mirrored by the relatively few coaches who stated that they utilize HWI and saunas in HA, with both techniques only supported by 15.8% of the coaches. Given the support for these HA strategies in recent research, it is a surprise to see how few coaches utilize these methods (Zurawlew et al., 2018; Zurawlew et al., 2016). As this research was published recently, at the time of this study, it may be that these strategies are too novel and the effectiveness has not been communicated to most coaches. It is also possible that many coaches do not have access to facilities that allow for HWI post-exercise. Interestingly, coaches with higher levels of education were associated with engaging in passive heat exposure techniques. It is possible that coaches with higher levels of education may be most up to date with current research.

The use of acclimatization to the natural environment was the most common heat exposure technique used by coaches during a HA program with 73.7% of the sample responding that they use this technique. This strategy was associated with the geographic location of participants. Unsurprisingly, coaches at schools in southern locations utilized the natural environment most readily. It is also unsurprising that coaches in these locations who could most easily make use of warm climates reported the most confidence in the availability of resources to prescribe an effective HA protocol. Using the natural environment may provide a significant advantage to coaches at schools in southern locales. Consensus recommendations highlight effective HA protocols mimicking competition conditions as closely as possible and utilizing the natural environment to bring about more specific and robust thermoregulatory adaptations (Racinais et al, 2015).

In the current study, 70% of the coaches located in northern geographic locations and high-altitudes use excess clothing as a heat exposure method. This may be due to an inability to use a warm-natural environment to acclimatize to. Though the use of excess clothing as a heat exposure method is still an understudied topic, recently researchers suggested excess clothing in a temperate environment can introduce the requisite heat strain to induce HA, though it may not be as effective as exercise in exercise in high-heat (Ely et al., 2018). While exercise in excess clothing can increase core temperature, excess clothing elicits a lower skin temperature and HR than exercise in just high-heat conditions (Willmott et al., 2018). Excess clothing may provide a stimulus to induce some thermoregulatory adaptations, however, further research into the use of excess clothing should investigate whether this method provides robust adaptations that improve athletic performance. When utilizing excess clothing to generate heat exposure, parts of the skin surface (face, hands, head etc.) may still be exposed to the natural environment, allowing for effective sweat evaporation and reduced overall heat stimulus. To clarify the effectiveness of this strategy, research investigating the magnitude of HA generated from the use of excess clothing should be evaluated at various levels of body coverage. Heat stimulus could also be evaluated through a variety of different levels of clothing insulation as measured by CLO units, a unit of measurement that quantifies the thermal insulator capacity of clothing. Research on this topic would be particularly prudent due to functionality and widespread use of this method of heat exposure.

Coaches provided a wide array of responses when asked about the time frame they prefer to begin HA relative to peak competition. While 26.3% of coaches surveyed preferred to begin a HA program within the two weeks leading into peak competition, the rest preferred dates much further out, including 15.8% who responded that they prefer implementing HA in the pre-season and base training phases. Few researchers have investigated the periodization of HA in the broad scheme of a training cycle. While Pryor et al. (2019) hypothesized an ideal HA training structure over the span of an entire season, months-long research would be needed to establish ideal HA periodization during an entire training cycle.

One of the largest limitations to this survey was the low response rate and sample size. The 21 survey participants came from a pool of 190 coaches that were sent direct recruitment emails. The low response rate can likely be attributed to the events surrounding the time of survey dissemination. The survey was conducted in summer 2020 during the COVID-19 pandemic. Among the multitude of societal and cultural effects of this pandemic was the uncertainty surrounding organized collegiate athletics. During the time of survey dissemination, many coaches contacted may have been faced with particular uncertainty of the commencement of their respective sports and may have been unable to participate in this survey. In addition, many coaches may have been unable to access their offices during the survey collection period due to campus access restrictions related to the COVID-19 pandemic. This survey was not representative of the entire NCAA in terms of Division level, as no NCAA Division II coaches participated in this survey. Future surveys should ensure participation of coaches from all levels. Despite the small sample size, the sample was largely comprised of successful coaches of both women's' and men's' teams who had participated in the NCAA national championships within the last 5 years. In terms of experience, the coaches sampled displayed a variety in the number of years coached. While the survey produced many key insights, future surveys directed at the same population may be better served by being disseminated earlier in a summer period for a longer period of time and during a more stable year for collegiate athletics.

In summary, the findings of this survey support the need for further research in the use of HA training in an athletic program to maximize performance. The lack of consensus among coaches suggests not only a lack of quality applied research into the use of HA in the real world, but a gap between current research and the application by coaches. This research-to -practice gap of high-level coaches is likely due to ineffective knowledge transfer strategies by researchers. Improvements to these strategies could include more researcher-coach interaction and the production of articles that utilize more "lay" language. Additionally, the use of excess clothing as an inexpensive and functional method for heat exposure during HA warrants further research. Follow-up surveys should include coaches at various levels, ask specifically what the primary limitations to effective HA programs are, and highlight the periodization of a HA program within a larger training cycle.

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APPENDICES

APPENDIX A

IRB APPROVAL LETTER

IRB
INSTITUTIONAL REVIEW BOARD
Office of Research Compliance,
010A Sam Ingram Building,
2269 Middle Tennessee Blvd
Murfreesboro, TN 37129

MIDDLE TENNESSEE STATE UNIVERSITY

IRBN007 – EXEMPTION DETERMINATION NOTICE

Thursday, July 16, 2020

Principal Investigator	**Robert Macon** (Student)
Faculty Advisor	Richard Farley
Co-Investigators	Jennifer Caputo and Samantha Johnson
Investigator Email(s)	*nm3r@mtmail.mtsu.edu; richard.farley@mtsu.edu*
Department	Health and Human Performance - Exercise Science
Protocol Title	***Collegiate Cross Country and Track & Field Coaches Heat Acclimation Survey***
Protocol ID	**20-1202**

Dear Investigator(s),

The above identified research proposal has been reviewed by the MTSU Institutional Review Board (IRB) through the **EXEMPT** review mechanism under 45 CFR 46.101(b)(2) within the research category *(2) Educational Tests* A summary of the IRB action and other particulars in regard to this protocol application is tabulated as shown below:

IRB Action	**EXEMPT from furhter IRB review******	Date	**7/14/20**
Date of Expiration	**7/31/2021**		
Sample Size	50 (FIFTY)		
Participant Pool	**Healthy adults (18 or older) - Long-distance collegiate coaches**		
Exceptions	1. Online consent followed by internet-based survey using Qualtrics is permitted (Qualtrics links on file). 2. Survey Monkey platform is permitted for data collection		
Mandatory Restrictions	1. Participants must be 18 years or older 2. Informed consent must be obtained from the participants 3. Identifying information must not be collected		
Restrictions	**1. All restrictions for exemption apply.** **2. Mandatory active informed consent with age-verification.** **3. NOT approved for in-person data collection.**		
Approved IRB Templates	IRB Templates: Online informed consent script Non-IRB template: Recruitment script		
Funding	NONE		
Comments	Reer to the Post-Approval section for important COVID-19 instructions		

***Although this exemption determination allows above defined protocol from further IRB review, such as continuing review, MTSU IRB will continue to give regulatory oversight to ensure compliance.

Summary of Post-approval Requirements:

The investigator(s) indicated in this notification should read and abide by all applicable post-approval conditions (refer "*Quick Links*" below for more information):

- PI must close-out this protocol by submitting a final report before **7/31/2021**; if more time is needed to complete the data collection, the PI must request an extension. NO REMINDRES WILL BE SENT. **Failure to close-out (or request extension) may result in penalties** including cancellation of the data collected using this protocol or withholding student diploma.
- IRB approval must be obtained for all types of amendments, such as:
  - Addition/removal of subject population and sample size
  - Change in investigators
  - Changes to the research sites – appropriate permission letter(s) from may be needed if the study will be conducted at a non-MTSU location
  - Alternation to funding
- Modifications to procedures must be clearly described in an addendum request form and the proposed changes must not be incorporated without an approval
- The proposed change must be consistent with the approved protocol and comply with exemption requirements
- Research-related injuries to the participants and other events , such as, deviations & misconduct, must be reported within 48 hours of such events to compliance@mtsu.edu

Post-approval Protocol Amendments:

The current MTSU IRB policies allow the investigators to implement minor and significant amendments that would not result in the cancellation of the protocol's eligibility for exemption. ***Only THREE procedural amendment requests will be entertained per year. This amendment restriction does not apply to minor changes such as language usage and addition/removal of research personnel.***

Date	Amendment(s)	IRB Comments
07/16/2020	The online survey link updated with a Qualtrics link.	IRBPA2020-157

Post-approval IRB Actions:

Date	IRB Action(s)	IRB Comments
07/14/2020	The Faculty Advisor (FA) is given the administrative authority to make the necessary amendments to protect the health and welfare of participants and student researchers during the COVID-19 National Emergency. The FA must, however, notify the IRB (via simple emails or through standard amendment documentation) after such changes were made. The IRB will audit the amendments at a later date and will suggest remedial measures if needed..	COVID-19

Mandatory Data Storage Requirement:
All research-related records (signed consent forms, investigator training and etc.) must be retained by the PI or the faculty advisor (if the PI is a student) at the secure location mentioned in the protocol application. The data must be stored for at least three (3) years after the study is closed. Additionally, the Tennessee State data retention requirement may apply (*refer "Quick Links" below for policy 129*). Subsequently, the data may be destroyed in a manner that

maintains confidentiality and anonymity of the research subjects. **The IRB reserves the right to modify/update the approval criteria or change/cancel the terms listed in this notice.** Be advised that IRB also reserves the right to inspect or audit your records if needed.

Sincerely,

Institutional Review Board
Middle Tennessee State University

Quick Links:

- Post-approval Responsibilities: http://www.mtsu.edu/irb/FAQ/PostApprovalResponsibilities.php
- Exemption Procedures: https://mtsu.edu/irb/ExemptPaperWork.php
- MTSU Policy 129: Records retention & Disposal: https://www.mtsu.edu/policies/general/129.php

APPENDIX B

INFORMED CONSENT

Primary Investigator: Robert Macon
PI Department & College: Department of Health and Human Performance, College of Behavioral and Health Sciences
Faculty Advisor: Dr. Richard Farley
Protocol Title: Collegiate Cross Country and Track and Field Coaches Heat Acclimation Survey
Protocol ID: 20-1202 Approval Date: 7/14/2020 Expiration Date: 7/31/2021

The purpose of this study is to survey collegiate cross country and track and field coaches on their use of heat acclimation strategies to improve athlete performance. This survey is being conducted to catalogue various heat acclimation strategies coaches use as well as the potential limitations to heat acclimation programs that coaches identify.

You will be asked to complete a 16-question survey. The content of these questions includes demographic information, your opinions of the effectiveness and feasibility of heat acclimation programs as a collegiate coach, and specific characteristics of heat acclimation programs that you have designed. You will only be asked to fill out the 16-question survey once. Your participation in this study will take no longer than 20 minutes.

There are no risks of participating in this research investigation. you will merely answer the 16-question survey and submit your answers. Your participation in this survey will give researchers a better understanding of how high-level coaches design heat acclimation programs in the real-world.

All answers will remain anonymous. You will NOT be asked to provide identifiable personal information. The aggregate data will be used to characterize the "real word" utilization of heat acclimation programs utilized by collegiate coaches of endurance runners.

These are your rights as a participant:

- Your participation in this research is voluntary.
- You may skip any item that you don't want to answer, and you may stop the experiment at any time.
- If you leave an item blank by either not clicking or entering a response, you may be warned that you missed one, just in case it was an accident. However, you can continue the study without entering a response if you didn’t want to answer any questions.
- Some items may require a response to accurately present the survey.

All efforts, within reason, will be made to keep your personal information private but total privacy cannot be promised. Your information may be shared with MTSU or the government, such as the Middle Tennessee State University Institutional Review Board, Federal Government

Office for Human Research Protections, if you or someone else is in danger or if we are required to do so by law.

If you should have any questions about this research study or possibly injury, please feel free to contact Riley Macon by email at rrm3r@mtmail.mtsu.edu OR my faculty advisor, Dr. Richard Farley, at richard.farley@mtsu.edu or (615)-898-5298. You can also contact the MTSU Office of compliance via telephone (615 494 8918) or by email (compliance@mtsu.edu). This contact information will be presented again at the end of the experiment.

Participant Response Section

☐No ☐Yes I have read this informed consent document pertaining to the above identified research
☐No ☐Yes The research procedures to be conducted are clear to me
☐No ☐Yes I confirm I am 18 years or older
☐No ☐Yes I am aware of the potential risks of the study

By clicking below, I affirm that I freely and voluntarily choose to participate in this study. I understand I can withdraw from this study at any time without facing any consequences.

☐ NO I do not consent
☐ Yes I consent

APPENDIX C

COLLEGIATE CROSS COUNTRY AND TRACK AND FIELD COACHES HEAT ACCLIMATION SURVEY

PART 1- Please select all that apply

1. What level of collegiate athletics do you coach?
   a. Division I
   b. Division II
   c. Division III
   d. NAIA
   e. NJCAA

2. What is your coaching role on the team?
   a. Head Coach
   b. Assistant Coach
   c. Other Position unspecified (please elaborate in space provided)

   ____

3. What is the sex of the team you coach?
   a. Male
   b. Female
   c. Both

4. Please fill in the U.S. state in which you currently coach

   ____

5. What is the total number of years you have been coaching at the collegiate level?
   a. 0-9 years
   b. 10-19 years
   c. 20-29 years
   d. 30 years or more

6. Have you been a coach on a team that has qualified for the National Cross Country Championships for your respective collegiate division in the last 5 years (2015-2019)?
   a. Yes
   b. No

7. What is the highest level of education you have earned?
    a. High School Diploma
    b. Bachelor's Degree
    c. Master's Degree
    d. Doctorate Degree

PART 2- Please select the number that corresponds with your level of agreement to the following statements

1. I prescribe heat acclimation interventions to give my athletes a performance advantage in anticipation of competition in hot conditions.

1	2	3	4	5
(Never)	(Rarely)	(Sometimes)	(Often)	(Always)

2. I prescribe heat acclimation interventions to give my athletes a performance advantage in competitions in all climates.

1	2	3	4	5
(Never)	(Rarely)	(Sometimes)	(Often)	(Always)

3. I feel I have adequate resources (environmental or otherwise) to prescribe an optimal heat acclimation intervention.

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

4. I feel my athletes can maintain the training intensity required to perform at their best while undergoing heat acclimation.

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

PART 3- Select all options that apply when prescribing a heat acclimation program to your athletes

1. How many heat exposures do you prescribe to your athletes in a heat acclimation program in preparation for competition?
   - **a.** Less than 7
   - **b.** 7-14 exposures
   - **c.** More than 14 exposures

2. What is the duration of time in heat exposure you generally prescribe to your athletes for an individual bout in the heat?
   - **a.** 40 minutes or less
   - **b.** 41 minutes- 60 minutes
   - **c.** 61 minutes- 90 minutes
   - **d.** More than 90 minutes

3. What exercise intensity/intensities do you prescribe to your athletes while undergoing heat exposure?
   - **a.** Light-to-moderate intensity exercise (about 130-160 bpm)
   - **b.** High intensity exercise (about 160 bpm and up)
   - **c.** All exercise intensities are used
   - **d.** Prefer passive heat exposure. Athletes do not exercise in the heat.
   - **e.** If preferred intensity is not listed, please describe below

____

4. Which of the following method/methods do you use to expose your athletes to heat? (Select all that apply)
   - **a.** The natural environment
   - **b.** A climactic chamber
   - **c.** Excess clothing
   - **d.** Hot water immersion
   - **e.** Sauna
   - **f.** If preferred method is not listed, please describe below

____

5. How many days prior to peak competition do you have your athletes begin a heat acclimation program?

   a. Less than 7 days
   b. 7-13 days
   c. 14-20 days
   d. 21-42 days
   e. I prefer to prescribe heat acclimation programs in the pre-season or base building phase
   f. If preferred timing is not listed, please describe below

APPENDIX D

RECRUITMENT EMAIL

RE: Invitation for Participation in a Research Survey Focused on Collegiate Coaches

Primary Investigator: Robert Macon
PI Department & College: Department of Health and Human Performance, College of Behavioral and Health Sciences
Faculty Advisor: Dr. Richard Farley
Protocol Title: Collegiate Cross Country and Track and Field Coaches Heat Acclimation Survey
Protocol ID: 20-1202 **Approval Date: 07/14/2020** **Expiration Date: 07/31/2021**

Dear Coach,

My name is Riley Macon, I am contacting you to ask for your participation in a research study that I am conducting as my Thesis for an M.S. degree in Exercise Science within the Department of Health and Human Performance at Middle Tennessee State University.

The purpose of this study is gain insight into the use of heat acclimation training of high-level endurance athletes in order to improve performance. We are recruiting coaches of collegiate distance runners who are involved in prescribing training to high-level endurance athletes.

Your participation in this 16-question survey will take no longer than 10 minutes. There will be no personal risk from your participation in this study. No personally identifying information will be recorded. By participating in this survey, you will help researchers gain valuable knowledge that will drive future heat acclimation research as it relates to aerobic sport performance.

You are free to abstain from participation in this survey and can opt out of the survey at any point prior to survey completion. This survey will conclude 8/11/2020. There is no monetary compensation associated with participating in this investigation. If you have any questions, I can be reached at rrm3r@mtmail.mtsu.edu. My faculty advisor, Dr. Richard Farley can also be reached at richard.farley@mtsu.edu.

Please enter the survey by clicking the link at the bottom of the email. You will be given a chance to read the entire informed consent to assist you in making a final decision on participation. Thank you for reading, I eagerly await your response to this survey.

Sincerely,

Riley Macon

https://mtsu.ca1.qualtrics.com/jfe/form/SV_bDCjOeTdUOgh4S