Fluid Losses of Division III Track Athletes Experienced

During Indoor Versus Outdoor Seasons

by

Melanie Mertes

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Anne Hoel, PhD

Brian Bergquist, PhD

Anoop Balachandran, MS

The Graduate School

University of Wisconsin-Stout

May, 2009

The Graduate School

Menomonie, WI

Author: **Mertes, Melanie J.**

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ABSTRACT

Each year exercise-induced heat stroke is a leading cause of death among high school and college athletes. Numerous studies state that each year decreased athletic performance, severe health problems and even death can be traced back to dehydration. Previous hydration research and recommendations have been based on exercise in hot, humid, outdoor environments. Studies suggest great caution is merited under hot, humid conditions in response to the resulting increase in water losses, but little is known about the contrasting dry, indoor environment, therefore few recommendations exist.

This study proposes assessing fluid losses of Division III track athletes during indoor and outdoor seasons to quantify relative water losses in each environment. This

study hypothesizes humid weather and dry weather will manifest similar fluid losses, due to the nature of their water draining properties.

Monitoring body weight before and after exercise allows athletes to easily monitor individual sweat rates and fluid needs. This study aims to quantify fluid losses of athletes during both seasons and compare them. The purpose is to learn more about fluid losses in a controlled, dry environment. Hydration is essential in all sports, and failure to maintain hydration can be fatal for athletes of all shapes and sizes.

The Graduate School

University of Wisconsin Stout

Menomonie, WI

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Dedication

I dedicate this Thesis to my mom and dad, Lynn and Russ Mertes. They have been the most supportive parents any person could ask for throughout my entire life. During my schooling they have provided me with an outstanding amount of love, encouragement and prayer. Trying times have fallen upon my family, as my father has been diagnosed with terminal cancer, reoccurring from a bout he had overcome just a couple years prior to this one. It is very trying and difficult to be away from home in times like this. However, my parents have offered endless encouragement from a distance, understanding that I need to finish what I have started despite this hard reality. Being so far away from home is not easy at this time, but I am determined to finish this for my dad and mom alike. My father and I have been blessed with many memories together. I can think of nothing that makes him happier than to see his loved ones succeed, even when I out fish him every time. Dad never gives up and is going through unimaginable treatments to be here with us, creating the most memories he can. I know he is suffering for us, as he will proceed to a place of peace and no anguish when his time comes. So, all I can do is work my hardest to make him proud. This research paper signifies a huge step in my Graduate career and has been a source of pride for my dad as he talks to family and friends. I cannot wait to walk across the stage at my graduation and know my dad will be there waiting for me at the other end to congratulate me for all of my hard work with a big hug. This may be my last big accomplishment that he gets to witness, but one thing is for sure; it will be a great moment knowing that I did this for him and made him proud. I love you dad and I thank you and mom so much for all that you are and that you have made me become. This one's for you!

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Chapter I: Introduction

Introduction

Corey Stringer, Rashidi Wheeler, Thomas Herrion and approximately 680 other people each year in the United States share a scary statistic (CDC, 2006). They approximate the deaths attributed to dehydration and heat related injuries every year. Exact numbers are difficult to obtain, as the incidence of dehydration-related injuries are too numerous to be recorded, but every year many deaths and injuries occur in athletes, which could easily be prevented (Oppliger & Bartok, 2002). Many people understand the importance of hydration during prolonged activities, but fail to fully comprehend the many health risks associated with improper hydration. Studies indicate that every year severe dehydration results in not only decreased athletic performance, but also health problems and even death (ACSM, 2004; Oppliger & Bartok, 2002; Rehrer, 2001; Sawka, Burke, Eichner, Mauhan, Montain & Stachenfeld, 2007; Shirreffs, 2005; Watson, Judelson, Armstrong, Yeargin, Casa & Maresh, 2005). In virtually every sport, athletes experience lost training/competition time, performance decrements, discomfort and in some cases, hospitalization related to dehydration. The all-to-frequent deaths and many near misses are indication that an athlete's state of hydration should be monitored more closely (ACSM, 2004; Oppliger & Bartok, 2002).

Physical activity exposes individuals to a variety of factors that influence sweat loss including: duration of exercise, intensity of activity, environmental factors and/or the types of clothes and equipment worn by athletes (Sawka et al. 2007). Sweat-rates also vary individually based on factors like body weight, body composition, genetic predisposition, heat acclimatization status, metabolic efficiency and dietary intakes. As exercise endurance and intensity increase, fluid and electrolyte losses also increase. Unless losses are compensated for with appropriate water and electrolyte intakes, problems will occur (Rehrer, 2001; Cheng & McLellan, 1998). Athletes who are more fit and environmentally acclimatized will sweat sooner and more than athletes who are less fit (Cheung & McLellan, 1998; Nielsen, Hales, Strange, Christensen, Warberg & Saltin, 1993; Oppliger & Bartok, 2002). In addition, athletes of all fitness levels will experience decreased tolerance time and lower sweat evaporation ability as well, even in athletes acclimatized to exercising in the heat. It is critical to insure that all athletes understand how to recognize, monitor and treat water/sweat losses at each individual's personal rate to insure his or her safety and optimal performance. It's equally important to encourage athletes to drink whether or not they are thirsty or feel as though they are sweating or experiencing fatigue, as dehydration often goes unnoticed. It is said that by the time thirst is perceived a body water deficit of 1-2 % has already incurred, putting athletes in a state of moderate dehydration (Rehrer, 2001; Watson et al., 2005).

Studies suggest that for optimal exercise performance and health maintenance, it is critical to attain fluid and electrolyte balance in each athlete (Cheung & McLellan, 1998; Sawka et al., 2007; Shrieffs, 2005). It is, however, a common concern that ultra-endurance athletes typically do not consume fluids in quantities to offset fluid lost during exercise. Athletes commonly count on thirst as an indicator of when to drink, but as aforementioned, this method alone is not enough (Rehrer, 2001). Furthermore, studies indicate that many athletes, up to 87%, arrive to their sporting events already experiencing some state of dehydration (Finn & Wood, 2004; Watson et al., 2005). Fortunately, there are methods of hydration testing that can be easily performed by players, coaches, and medical staff to ensure the health and safety of athletes (Oppliger & Bartok, 2002). There are two methods, which are both inexpensive and relatively simple for coaches to employ and athletes to abide by in order to ensure euhydration (Finn & Wood, 2004). The most common methods consist of monitoring weight loss along with fluid intake and individual monitoring of urine color. These and other hydration issues will be talked about in more depth in Chapter II.

During any given school year, the UW-Stout track team competes in two seasons, with their indoor season running from October through mid March and their outdoor season running from mid March through May. During this time, athletes undergo a variety of rigorous drills and training in order to prepare for their respective competitions and may practice for hours each day, depending on their respective events and competition schedules. Many athletes will practice twice in one day, be it two cardio sessions, one cardio and one weight-lifting session or practice and other intramural or extra-curricular activities. Studies indicate that when a second exercise bout is performed on the same day, it may induce a larger neuroendocrine response than the first exercise bout. This may suggest a greater need for water intake during the second bout of exercise and increase the importance of monitoring weight changes and fluid replacement. When multiple workouts occur within the same day, especially in hot/humid conditions, it's hard for athletes to return to a euhydrated state, even when proper hydration monitoring protocols are in place (Li Li & Gleeson, 2005; Oppliger & Bartok, 2002). If multiple activities occur daily, it becomes increasingly difficult to calculate accurate fluid balance based on bodyweight changes, as weight change may reflect energy imbalance and tissue wasting due to the loss of glycogen and fat (Godek, Godek & Bartolozzi, 2005).

Studies have shown a minor confliction in the actual fluid loss an athlete will experience. One study expressed that football players can lose 3.5 to 5kg (7-11 pounds) of fluid during daily practices due to heavy sweating (based on a calculation of ~2L lost per hour) when practices last up to 4.5 hours (Godek et al., 2005). In another study performed by the same researchers, they found that sweat losses in runners and football players could be quite comparable depending on the intensity and/or duration of the exercise. They specifically tested pre-exercise, mid-activity, and post-activity core temperatures of both athletes to compare them later. Findings in this study showed that core temperature of football players was significantly higher than runners pre-practice, but significantly lower post-practice. Core temperature showed to be the higher in the runners mid-practice than football players and was higher in the football players when they were active, as opposed to during water breaks. Both groups of athletes experienced their highest core temperatures post-practice. The study also found that runners tended to drink, on average, only at mid-run and post-run, where as football players generally took water breaks about every 15 minutes, suggesting that runners were less likely to replace fluid losses from sweat as adequately as football players. It was concluded that runners exercised continuously at a moderate to high intensity, where as football players exercised intermittently, causing a gradual increase in core temperature in runners and an increase and decrease in response to activity level in football players (Godek, Godek & Bartolozzi, 2004). This phenomenon has become so prevalent that the American College of Sports Medicine (ACSM), the American Dietetics Association (ADA) and the National Athletic Training Association (NATA) have all set guidelines for fluid replacement and the composition the fluid replacement requires. Overall, it's critical to recognize that weight loss is individualized based on variance of events, effort, weather conditions, body weight, body composition, genetics, et cetera and that each component contributes to an individual's varying water loss. When practices occur twice a day, especially on consecutive days, promoting good hydration becomes an increasingly important issue.

Increased concern is expressed in regards to the large amount of fluid lost during times of intense heat and humidity. Athletes' systems are said to be at an increased risk for injury and dehydration in extreme heat due to the body's increased level of work while attempting to keep the body cool throughout exercise. Heat-related deaths occur every year in both college and high school sports, which frustrates many researchers, considering most are preventable. The all-too-frequent deaths and close calls indicate that hydration status of athletes should be monitored more closely (Godek et al., 2005; Oppliger & Bartok, 2002). Regardless of acclimation status, as body heat rises, bodily systems, such as the cardiac, respiratory, endocrine and exocrine work at higher than normal rates to compensate for the increased stress heat places on the body. At this point, maintaining body function and cooling both internal and external body temperature become the highest priorities. Sweat evaporation is the primary mechanism of heat loss during vigorous exercise, which can cause substantial fluid losses. Sweat contains mostly water, along with electrolytes, which can adversely impact an individual during exercise if not properly replaced. Chapter II will provide more in depth information on the systems stressed during exercise, what is lost and how to replace losses.

Little data is published today on sweat loss and water intake while exercising in an indoor environment or even in a cool environment, especially in regards to runners.

Likewise, few studies exist on the hydration status of sprinter runners and their state of euhydration with intense practices, whether looking at practice indoors or outdoors. However, one such study performed on elite soccer players practicing in a cool, indoor environment showed that sweat losses were not different from those experienced by players training at a comparable level in a much warmer environment (Maughan, Shirreffs, Merson & Horswill, 2004). Another study found that inadequate pre-game and post-game hydration status was seen in athletes training in a dry climate, which was in this case a dry, tropical climate (Finn & Wood, 2004). One other study performed on indoor cyclists also showed significant weight losses occurring in participants and is discussed further in chapter II (Hazelhurst & Classen, 2006). With minimal studies available on the effects of exercising indoors and the inability to find any specific to runners, it is important to learn more about the effects practicing in a dry, indoor environment has on the sweat losses of runners. Living in northwestern Wisconsin, much of the track season and running careers of these Division III athletes occur indoors and therefore it is critical to understand how this environment will affect their hydration status, and furthermore their performance levels.

Several questions should be considered by every sports team in regards to dehydration and will be addressed in this study. What complications and possible dangers are associated with dehydration? What is a significant water loss and how much should be replaced? When is the best time to hydrate athletes? What types of fluids should be offered to replace what is lost in sweat? Finally, the practice environment athletes endure regarding temperature, clothes and equipment worn, length of practices, recovery time between practices and many other factors.

Statement of the Problem

The purpose of this investigation is to assess fluid balance of University of Wisconsin Stout Division III track athletes. For one week of indoor season practices and one week of outdoor season practices the researcher will monitor athlete's weight before and after practice along with any water consumed between weigh-ins. Furthermore, data will be tested to see if a correlation exists between the two seasons and if there is a correlation between the water intakes and sweat losses of each respective season. Data will be collected at UW-Stout over a one-week period in December 2007 and a one-week period in April 2008. Three data collections will take place in each of these weeks, in order to calculate an average weight loss and percentage of body weight loss for each individual.

Hypotheses

Fluid losses in both environments will be significant, defined as an average weight loss of greater than or equal to 1.5% of pre-exercise body weight, for both the sprinter and distance runners.

Fluid losses in a dry, controlled, indoor environment will be equal to or greater than fluid losses in an uncontrolled, outdoor environment for both groups of runners.

There will be no apparent correlation between the sweat losses and the volume of fluid consumed in each individual season (indoor and outdoor) for either group of runners.

Definition of Terms

The following terms will appear in this document and are defined with the intention of a better understanding of their intended meaning for this paper.

Dehydration: The process of body water loss, which if not treated will eventually lead to hypohydration.

Euhydration: A state of "normal" body water content or being in equal balance of fluid and electrolytes.

Hydration: Drinking a balanced amount of water to help replace losses and keep electrolytes in balance

Hyperhydration: When excess body water content is experienced.

Hypohydration: When body water content deficits are experienced.

Hyponatremia: A condition of electrolyte imbalance where plasma sodium levels fall below normal and can lead to water intoxication.

Rate of Perceived Exertion: A scale to rate how heavy and strenuous exercise feels to the athlete. See Appendix A for a complete outline of this scale.

Strenuous Exercise: Any physical activity lasting more than 90 minutes working at a rate of 50% or more than the maximum possible.

Significant Weight Loss: Defined as a weight loss of greater than or equal to 1.5% of starting body weight, individual to each athlete.

Assumptions

When embarking upon this study, the researcher made several assumptions. The first is that it's assumed the athletes in this study will perform consistently at rather high intensities, as they are practicing for collegiate competitions. The second assumption is that the weather the players practice in will be relatively consistent during the week of outdoor study, as to not profoundly alter sweat rates. Next it's assumed that the indoor track environment will be consistent during the duration of data collection, as the University has standards at which to keep various rooms stabilized at. Another assumption is that athletes are eating a relatively similar, balanced, and consistent diet to include salt and fluids in each meal. Lastly, it's assumed that the electronic scale used to measure athletes will be accurate and consistent from day to day and practice to practice.

Limitations of the Study

The following limitations should be considered, as they may impact the integrity of the study as it is performed and the results that it may yield. First, in this study systemic errors could be made in that all sources of body weight loss and gain are not taken into account. Next, like many similar studies, no correction will be made for the metabolism of carbohydrates, fats and proteins, nor the subsequent loss of $CO2$ over $O2$ gained. This study, for the most part, only reports bodyweight changes and fluid intakes, but fails to correct for metabolic bodyweight loss or water gain. Also, this study did not take into account the diets of the athletes or the composition of their diets, such as salt intake. The remnants of the diet that are excreted can influence fluid balance (Rehrer, 2001) as excretion of solutes from the kidney is always accompanied by water excretion caused by osmotic drag. Thus, with increased protein ingestion or breakdown, the production of urea is increased, which will increase urea output and therefore urinary water loss. Furthermore, a limiting factor could be inconsistency and reliability of the scale used, as it is possible, but unlikely, that it could vary from day to day. Finally, it is possible that during the spring in Wisconsin, the weather may present drastically different conditions which, as previously mentioned and latter studies state, could differ in how they affect weight loss in athletes (Finn & Wood, 2004; Godek, et al., 2004; Maughan, et al., 2004; Noakes, 2000; Oppliger & Bartok, 2002; Rehrer, 2001; Sawka, et al., 2007).

Chapter II: Literature Review

As a basis of understanding the body's cooling mechanism and how this contributes to the loss of fluids in the body, chapter II will provide an overview of hydration. What causes fluid imbalance, health and performance risks associated with improper hydration, environmental influences on hydration status, possible ways to prevent improper hydration, how to monitor status and how to better control it, will all be discussed.

Body cooling Mechanism and Sweat

Physiology. Along with exercise come a variety of complex bodily reactions that affect the rate at which a person will sweat. When a person exercises his or her core temperature will increase rapidly upon onset and continue to increase subsequently at a slightly slower rate until the heat lost from the body is equal to that of heat produced by the muscles, essentially reaching a steady state (Sawka, Wenger & Pandolf, 1996). When exercise is performed, metabolic heat production isn't the only thing that increases, as blood flow to the skin and muscles is also increased to facilitate heat loss from the body. When metabolic heat production is progressively increased with the progressive increase in exercise intensity, heat loss is proportionately increased due to the rising blood flow to muscles and skin (Garret & Kirkendalll, 2000). When skeletal muscles contract they form metabolic heat as a by-product, which when stored, increases the core temperature. Thermoregulatory effectors responses in the body are responsible for enabling a dry and evaporative heat loss increase that is proportional to the rate of this heat that is being produced. When exercise is started metabolic rate increases immediately, whereas thermoregulatory effector response for heat dissipation is slower at responding. Eventually, these two mechanisms will increase heat loss in a manner sufficient to balance the metabolic heat that is produced and to ideally produce a steady-state core temperature.

With exercise the body is an "inefficient machine" which allows only 25% of chemical energy used by exercising muscles to be converted into mechanical work, the remaining 75% is lost as heat. The rate of heat production by the body is linear to the function of running speed and intensity, and therefore running at a faster pace and higher intensity will cause an exponential rise in energy production and release (Noakes, 2000). In times of intense heat, the body's main cooling mechanism, sweating, shifts into high gear intending to cool both the internal and external temperatures, and maintain proper bodily function. To counteract these losses, numerous studies agree that hydration should occur not only prior to an exercise, but is important throughout exercise and should be stressed by coaches during practice settings in particular (Oppliger & Bartok, 2002; Ray & Fowler, 2004; Reynolds, 2006; Sawka, et al., 2007). Effects of dehydration can occur rapidly, especially when exercising intensely for more than sixty-minutes and in extreme conditions, so it is imperative that they be monitored (Schirreffs, 2005).

When the rate of muscle contraction increases, metabolic demands increase linearly with heat production. Physiologically the body responds by increasing circulation and the redistribution of blood flow, particularly to the muscle. As these changes occur, an increase in sweat production is seen in an effort to keep the body cool and at a lower core temperature. When this heat is evaporated off the skin, the most efficient cycle of heat loss available to humans is complete. With intense, long lasting exercise, sweat losses can be substantial and cause a critical reduction in body water (Rehrer, 2001). Environmental conditions such as hot temperatures and humidity can have an increased effect on this phenomenon, making water losses significant and often times deadly (Oppliger & Bartok, 2002; Rehrer, 2001; Sawka et al., 2007). When relative humidity is high, heat exchange between the environment and the skins' surface can be hindered manifesting an increased core temperature. This process is discussed further and in more detail later in the chapter (Reilly & Ekblom, 2005). The addition of non-breathable clothing or equipment, varying individual sweat rates and not replenishing from previous exercises make sweat losses increasingly difficult to control, monitor, and replenish.

Sweat rates. Another factor contributing to varying fluid loss is individual sweat rates. It's important for athletes and coaches to realize that individuals vary in their sweat rates considerably based on heat acclimatization, body weight, body composition, diet, genetic predisposition, gender et cetera (Schnirring, 2003). Similarly, further studies indicate that inter-individual variation in sweat response across time for each individual is based on: physical fitness, heat acclimation status, exercise intensity and duration and the amount and type of clothing worn (ACSM, 2004; Maughan, et al., 2005). Some older studies also indicate that gender plays a role in varying sweat rates as well (Avellini, Kamon & Krajewski, 1980; Frye & Kamon, 1981; Frye & Kamon, 1983; Shapiro, Pandolf, Avellini, Pimental & Goldman, 1980). A more current study done on indoor cycling participants supported these previous studies showing sweat rates to be higher in men (at 1.12L/h) than in women (at 0.57L/h) even when equal intensity was instructed and equal water was consumed (Hazelhurst & Claassen, 2006). Furthermore, one study stated that a diet high in fat would result in lower water production than a diet predominantly made up of carbohydrates. A diet high in protein and fat will result in ketosis, which can increase urinary water loss, contributing to dehydration (Rehrer, 2001). Studies also suggest that individuals with larger body mass will have greater daily sweat losses than those of smaller body mass (Sawka et al., 2007). Athletes typically portray a higher percentage of muscle mass due to their high levels of exercise and fitness, resulting then in the production of more heat (Rehrer, 2001). This is attributed to the phenomenon explained earlier stating that with more muscle working during exercise, more heat is created and needs to be released from the body.

The body and water. Water is the largest component of body mass and accounts for between 50-70% of bodyweight, and typically 60-70% of bodyweight in males. Most soft tissues contain 70-80% water and the remaining 20-30% of tissues is made of major molecular components known as proteins and various organic and inorganic compounds (Saravazyan, Ratarinov & Saravazyan, 2005). A bodyweight that is relatively stable is defined as being within 0.45kg of a person's usual body weight from day to day (Oppliger & Bartok, 2002). Daily water balance depends on the net difference between water gain and water loss. Gaining of water occurs through consumption of foods and liquids, as well as production of metabolic water. Losses occur from respiration, gastrointestinal, renal and sweat losses. It is important to note that for this study's purpose we take into account that metabolic water produced with cellular metabolism is about equal to respiratory water losses, so there is no net change in total body water (TBW). Also, unless a person experiences diarrhea, gastrointestinal water losses are very small and will not be accounted for in this study (Sawka et al., 2007). Studies agree that the primary cooling system of the body and the therefore main source of water loss during exercise and heat stress are sweating (Oppliger & Bartok, 2002; Reilly & Ekblom, 2005; Sawka et al., 2007).

Normal daily fluid requirements for a sedentary-active person range from 2-4L/day, when the climate is temperate and 2-4L/day when the climate is hot (Greenleaf, 1994). With high-intensity exercise, it is common for athletes to experience sweat rates of 1.0-2.5L/h, especially when exercising in the heat. These high sweat rates are not maintained at a continuous rate throughout exercise, but rather are dependent on individual needs of dissipating body heat (Garrett & Kirkendall, 2000; Sawka & Pandolf 1990). This level of loss has become so prevalent that the National Athletic Training Association and the American Council of Sports Medicine have made recommendations stating that weight lost during one training session should be regained by the next day's workout. The easiest method for monitoring this is to weigh athletes prior to each workout, allow them to towel-off post-workout and weigh them again (Oppliger & Bartok, 2002; Shrieffs, 2005). Further recommendations for recognizing, monitoring and replenishing fluid loss can be found in the following section.

Hydration Recommendation

Understanding the body's cooling mechanism of water loss through sweat, several other questions may come about such as how to monitor losses, what amount of fluid loss is significant, how much fluid should be replaced, when is the best time to hydrate athletes and what types of fluids will best replace what is lost in sweat? These questions will be explored with more depth in the following paragraphs.

Monitoring body water. Blood tests are said to be the most accurate means of monitoring hydration status, but are often impractical because of cost and the level of invasiveness (Oppliger & Bartok, 2002). There are, however, two relatively common and low-cost methods of monitoring fluid losses used in athletic programs throughout the United States. The first involves monitoring individual body weight fluctuation with exercise and the second is called urine color testing or monitoring. The study performed by Oppliger & Bartok (2002) suggests that body water measurements may give the most accurate information about body hydration status in the respect that weight loss generally corresponds to water loss. It implies that by taking daily measurements, accurate tracking of body water over time can encourage athletes to stay well hydrated on a daily basis. Similarly, a second study states that body weight measurements provide simple and effective assessment tools in regards to fluid balance. Monitoring these acute changes in TBW during exercise, sweat rates can be calculated using weight before exercise, accounting for fluid taken in during practice and any urine loss and then weighing after exercise, recording any changes. This body weight change can reflect sweat loss during exercise and provide a standard for individual fluid replacement needs (Sawka et al., 2007). Both the American Council of Sports Medicine and the Institute of Medicine of the National Academies suggest that weighing oneself before and after exercise is the only way to calculate and therefore control for varying sweat rates. The latter suggests drinking no more than one cup of water every twenty minutes, as no more will be absorbed, and that each pound of sweat lost is equal to sixteen-ounces of fluid (Quinn, 2008).

The second method of monitoring hydration status is accomplished by having athletes monitor their urine color. Conflicting opinions exist concerning the accuracy of monitoring urine color, but most studies seem to agree this is a basic, useful way to assess whether or not enough fluid is being ingested. One study states that urine color alone is not enough of an indication of whether euhydration is being achieved. It suggests that a dehydrated person consuming a large volume of fluid may present with light colored urine long before euhydration is attained. This is explained by ingesting a high volume of fluid in a short period and basically immediately excreting it to show a falsely lighter reading. An athlete would then apparently reflect a euhydrated state, when in fact they are still dehydrated (Sawka et al., 2007). Another study contrasts this theory suggesting athletes should frequently monitor their urine color moreover; if it is pale in color they can assume they are ingesting enough fluids to help replace losses (Rehrer, 2001). A further study supports both opinions of this issue stating monitoring urine color is a good indicator of hydration status as their study showed as urine color increased, urine specific gravity also increased. The study states that urinalysis is a valid and reliable method to determine moderate changed is fluid balance, which will be collected as urine specific gravity. This same study states that urine color tended to underestimate hydration levels in their study, however, results still supported urine color as a simple, inexpensive way to self-measure hydration status in athletes (Finn & Wood, 2004). A different study performed on athletes validated a six-point Likert color scale to use for monitoring urine color, or Ucol as they called it (see Appendix B). This is available in a pocket size form for athletes to carry around in an effort to encourage color monitoring. Under normal conditions, urine should manifest a pale to light yellow or straw-like color. According to this scale a Ucol of >3 on the Likert color scale is representative of a state of dehydration (Oppliger & Bartok, 2002).

Dehydration. The effects of dehydration can cause many problems including decline in performance, severe injury and possibly even death. Each year training and performance time is lost due to the effects of dehydration and heat-related illnesses, making it important to understand the extent to which dehydration can affect the body. Mildly significant dehydration is said to occur at a loss of as low as 1-2% of pre-exercise body mass (Watson et al., 2005). Dehydration occurring at a level of 2% of ones body mass throughout any type of endurance activity has been found significant enough to lead to a reduction in performance, especially if the exercise exceeds ninety-minutes (Oppliger & Bartok, 2002; Schrieffs, 2005). Some statistics show fluid loss significance as follows: 1% of body mass loss will cause the sensation of thirst, 2% will cause vague discomfort, 4% increases effort needed to perform physical work, 5% will cause difficulty concentrating, 6% impairs exercise temperature regulation and increases pulse and respiratory rate, 10% leads to spastic muscles and 15% will cause death (Hooper, Huges & Newcombe, 2005; Saravazyan, 2005). One study performed on runners racing 5,000 and 10,000 meters showed a slowing pace occurring when runners were induced with diuretic dehydration at just 1.6 -2.1% of their respected body mass. This same study suggested that as of the publication date, no studies existed on the affects mild dehydration has on running performance at distances less than or equal to 400 meters, suggesting that sprint performance may not be altered (Watson et al., 2005). Dehydration can reduce athletic performance and lead to such injuries as fatigue, cramps, heat exhaustion and heat stroke (Oppliger & Bartok, 2002, Sawka et al., 2007). Improper hydration may cause increases in heart rate, rates of perceived exertion (RPE), cardiovascular strain, heat strain and both core and muscle temperatures; as well as alter metabolic, central nervous system, physiological and cognitive functions (Lim, Byrne, Chew & Mackinnon, 2005; Rehrer, 2001; Shirreffs, 2005; Watson et al., 2005). Though many professionals, coaches and athletes are aware of this issue, the continuous deaths and severe injuries suggest that not enough is being done to control it.

Injury Prevention. To prevent commonly experienced injuries such as fatigue, cramps and heat stroke proper rehydration and the replacement of electrolytes should be stressed (Hsieh, 2004; Rehrer, 2001). Recommendations for fluid replacement protocols tend to vary from study to study. Some studies suggest that fluid consumed should equal fluid lost by comparing weight pre and post-exercise, or by using the USATF Self-Testing Program for Optimal Hydration, illustrated in Appendix C (Digate, 2005; IDEA, 2005). Others suggest that "by the time you feel thirst, you've typically lost at least two percent of your body weight" to dehydration. As a result these studies advise that athletes should not rely on thirst mechanisms to regulate when they drink (Reynolds, 2006; Schnirring, 2003). Early recommendations included: 17-20 oz, 2-3 hrs before and 7-10 oz, 10-20 min before, 7-10 oz every 15 min during exercise and at least 20 oz/lb weight lost within two hours after exercise (ACSM 2005; IDEA, 2005). More recently, however, the American Council of Sports Medicine has decided that blanket recommendations are no longer accurate, because each athlete's needs are so unique. Physiologists now suggest monitoring weight before exercise, any fluid consumed during exercise and weighing in after exercise. If an individual loses weight during exercise, they should drink more each hour and if they have gained weight, they should drink less to prevent hyperhydration or hyponatremia (Reynolds, 2006). Studies suggest that past recommendations of drinking liberally to keep up with fluid loss no longer holds fast, due to the possibility of hyperhydration (Hsieh, 2004; Schnirring, 2003). The study performed by Hsieh (2004) further suggests a moderate hydration rate of approximately 500mL/hour or less, compared to the previous recommendations of 1L/hour. Although Hyponatremia is becoming an increasing concern when considering fluid replacement, studies suggest that hyponatremia is not usually a phenomenon experienced in most sports, as long as players ingest adequate sodium. Issues are usually experienced in marathon runners who run for countless hours and choose no fluids with electrolytes in them (Schnirring, 2003; Godek et al., 2005). Since no clear, general recommendations can be made, this study will utilize the sweat rate equation. Weight lost during exercise (ounces) + Fluid consumed during exercise (ounces) = The amount (in ounces) one should drink to replace sweat loss (IDEA, 2005).

Who's at risk. A study performed by Watson et al (2005) suggested that the performance of sprinter runners may or may not be affected by dehydration, where as it affects many longer distance runners. In the study, racers of different lengths underwent diuretic-induced dehydration to determine the affects it had on different distances while running. For the 50 and 200 meter distances, the average decrease in body mass was between 0.8-2.5 kg (+/-0.5kg) in the dehydrated group and 1.3kg (+/- 0.4 kg) in the control group. For the vertical jumpers and the 400 meter runners, the average body mass decrease was 0.5kg-2.2kg (+/-1.1kg) in the dehydrated group and 1.1 (+/-0.6kg) in the control group. The study showed no difference between the control and dehydrated groups before and after the racing events (50, 200, 400 meters) in terms of thirst perception, thermal sensations or rate of perceived exertion. All of these responses increased at the completion of the races, except for thermal sensations, which remained constant in the 200 meter race. The primary finding of this study was therefore that the mild diuretic-induced dehydration did not alter performance at a 50, 200 and 400 meter race pace. One study supports these findings showing that the mean power of 30-second cycling bouts performed after 3.8 hours of baseball practice were not affected by a reduction of 2.5%, 1.7% nor 0.7% of body mass (Yoshida, Takanishi, Nakai, Yorimoto, & Morimoto 2002). Another study that contrasts these findings found that a loss of 2% of body mass induced by walking or jogging in hot and humid weather did in fact impair the velocity of performing a 20 second interval of running and walking (Maxwell, Gardner & Nimmo, 1999).

Related Studies. As discussed in chapter I, few studies have been published regarding sweat loss and water intake of athletes training in a cool environment. Even more relevant to this particular study, none could be found specific to runners. A few studies have been performed on how exercising in a cold environment will affect the body and the rate at which a person sweats. One such explanation is that breathing cold air will intensify body fluid loss during exercise due to the relationship between decreasing air temperature and decreasing saturation of vapor pressure. Cold air is actually said to have less water content than warm air regardless of relative humidity; therefore a greater loss (up to 50% more) of respiratory water is lost to humidify inspired cold air, as opposed to warm air when breathing in the cold. Though these losses account for a small percentage of overall body mass loss, exercising in the cold can still cause metabolic heat production. If the heat produced exceeds the loss of heat it will cause a rise in body temperature and initiate the thermoregulatory response for heat loss, sweating. One study reported that fit persons maintained warmer skin temperatures than less fit persons during rest in cold air due to higher metabolic heat production and a thinner subcutaneous fat thickness, which may affect sweat rates in colder environments (Garrett & Kirkendall, 2000).

Furthermore, in cold environments a phenomenon know as "voluntary dehydration" is often seen, which is manifested by cold weather blunting the thirst of athletes, causing them to restrict their fluid intake in an effort to minimize their need to urinate outdoors, cease activity or perceive thirst (Garrett & Kirkendall, 2000). Effects of any imbalance of fluid loss and fluid intake due to this phenomenon will worsen with duration of cold exposure and the prolonging of intense exercise performed in it. Bodily and performance impairments related to hypohydration are likely to be similar in both cold and hot environments. Some think that hypohydration may increase susceptibility to peripheral cold injuries, possibly in relation the decrease of blood flow to the peripheries or an impaired CIVD response to cold weather (Garrett & Kirkendall, 2000).

A study by Rehrer (2001) indicated that in cooler conditions, lower sweat rates likely incur and any prolonged moderate-to-intensive exercise will cause glycogen reserves to become limited before dehydration is significant, therefore causing performance to cease before dehydration occurs. Conflictingly, two studies suggest that average sweat rates in cool conditions may not be very different from those in warmer environments. Two possible explanations refer to the types of clothing worn or the amount of water consumed in a respected environment. They state that there may not be the same amount of water consumed or clothing worn while exercising in a cool environment versus a hot one, therefore bringing different variables into play. One of these studies was performed on football players and compared exercising in an ambient temperature of 10 degrees Celsius with that of 25 degrees Celsius, showing a respective weight loss of 1000 milliliters and 1200 milliliters, which were both significant and didn't vary much in respect to the temperature difference (Rehrer & Burke, 1996). Another study performed on seventeen elite soccer players practicing in a cool environment for 90 minutes assessed the body mass change in players, correcting for the volume of water consumed during the practice. The same authors had previously reported data on sweat losses and drinking behavior of two groups of elite soccer players training in a warm environment and so decided to perform a study in the cool environment as well. The second study found that despite cooler conditions, sweat losses were no different than those of the players training at a comparable level in a much warmer climate. Likewise, the study found that fluid volume consumed was smaller in the present study than those that had occurred in individuals exercising in the heat (Maughan et al., 2005). Furthermore, an additional study performed on exercise in a cold environment stated that the normal average temperature of skin is 33 degrees Celsius and that any lower temperature will cause heat to dissipate from the body into the environment as muscle contraction produces body heat. Thus, when heat is produced by muscles in a cooler environment, it will quickly be lost from the body into the cooler environmental conditions. He goes on to state that the humidity of the air will determine the extent to which heat can be lost to the environment in the form of evaporating sweat (evaporation). Therefore, a lower humidity (dry conditions) will allow more sweat to evaporate from the body, as the humidity, or water in the air, is very low and more evaporation can occur (Noakes, 2000). Supporting this theory, a different study states that if evaporative heat loss of the body is greater than that of the evaporative heat loss capacity of the environment, physiological strain, increased skin and core temperatures and an increased need to sweat can occur (Cheung & McLellan, 1998). Yet another study performed on male and female cyclists exercising indoors showed significant sweat losses in both groups and stated that both men and women left the spinning studio partially dehydrated with men losing 2.2% and women 1.5% of their initial body mass, due to sweat (Hazelhurst & Claassen, 2006). This supports the theory that significant levels of dehydration can occur while exercising indoors, increasing the need to study and attempt to understand just how greatly.

How much fluid to consume. Studies show that hydrating before exercise does not significantly enhance a person's heat tolerance regardless of acclimation status or aerobic fitness level (Cheung & McLellan, 1998). In other words, though professionals recommend drinking plenty of water hours, days and even weeks before performances, studies have proven that this alone will not sustain athletes. It is critical for athletes to remain hydrated throughout prolonged bouts of intense exercise, especially in a hot environment (Schrieffs, 2005). One study breaks down the rate at which fluid replacement should occur including pre-exercise, during exercise and post exercise. Pre-hydrating presents a goal of starting physical activity in a euhydrated state. Euhydration can be attained with sufficient food and beverage consumption, as well as allowing a recovery period of 8-12 hours in between exercise sessions. Generally hydrating prior to exercise should consist of slowly drinking about 5-7mL/kg of body mass at least four hours before the exercise task. If urine is dark or highly concentrated, it is then recommended that an additional 3-5ml/kg of body weight be consumed approximately two hours before exercising. Consuming small snacks and beverages containing sodium is important as well in an effort to replace electrolytes, also lost in sweat. During exercise, the goal of an athlete is to prevent excessive dehydration, defined as a loss of more than 2% of body mass. Additional consideration should be given to individual sweat rates, exercise duration, temperature and allowing adequate opportunities to drink (Sawka et al., 2007). Hypohydration can be prevented if fluid consumption is matched to sweat loss, but this is often difficult considering the thirst mechanism does not track body water requirements in an accurate fashion, as it is not perceived until a deficit of 2%. When athletes are left to drink ad libitum, as the track team is, incomplete replacement of body water loss is often seen. One study stated that heat-acclimated persons are likely to replace less than one-half of their fluid-deficit when consuming fluid ad libitum (Garrett & Kirkendall, 2000). In order to ensure that adequate hydrating is taking place, it can be helpful to monitor athlete's weight before and after practice to assess water losses (Oppliger & Bartok, 2002). After exercise the goal is to fully replace any fluid and electrolytes lost in sweat. If recovery time is sufficient, normal consumption of meals and snacks combined with an adequate volume of plain water will restore euhydration. Studies show that humans are typically able to fully rehydrate at mealtime, as the urge to drink is heightened by the intake of food at this time (Garett & Kirkendall, 2000). When possible, however, fluid should be consumed over time to prevent retention, as only so much water can be absorbed at one time. More specifically, most people can absorb a quarter liter of water per one quarter hour, where as some are more efficient and can absorb as much as one-quarter liter in only ten minutes. As a general recommendation, you should consume one-quarter of a liter with in ten to fifteen minutes after exercise (Tilton, 2008). Meals and snacks are recommended to contain salt in order to replace the sodium lost in sweat (Sawka et al., 2007). Even in understanding how essential adequate hydration is, many deaths are attributed to dehydration and heat related illnesses each year, suggesting there is still much to be learned and implemented.

What fluid to consume. Conflicting studies exist as to what type of fluid to consume in order to attain euhydration. Some imply carbohydrate and electrolyte-induced sports drinks are just as effective as plain water to regulate core temperature, heart rate (HR) and stroke volume, though they may taste better and prevent cramping (Byrne, 2004, Ray & Fowler, 2004; Rehrer, 2001). Supporting this statement, studies suggest that athletes will typically be enticed to drink more volume of a lightly flavored beverage than plain water and should drink whatever will keep them hydrated (IDEA, 2005; Godek et al., 2005; Sawka et al., 2007). Furthermore some studies recommend activities lasting an hour or more should be combined with 30-60 grams of an easily absorbed carbohydrate for each hour they are performed (Armstrong et. al, 2005; Digate, 2005; Hsieh, 2004).

A conflicting study proposes that although the glucose in sports drinks provides easily digested calories, these are not important in prolonged, high-intensity workouts. It continues by saying potassium losses during exercise are negligible and that not enough salt is present in these drinks to make a difference. Furthermore, an individual would "have to drink seawater, which has three times the sodium content of blood," in order to see any benefits (Reynolds, 2006). According to the International Marathon Medical Director's Association, when performing a workout consisting of 30 minutes or more one should alternate a sport drink with water, as the carbohydrates and electrolytes in sports drink will enhance faster water absorption and provide energy to the body (Maharam, Hew, Siegel, Adner, Adams, & Pujol, 2006). Essentially, all studies agree that any fluid intake is better than none and that more importantly athletes should concentrate on eating a balanced diet including sodium and plenty of water to reach and maintain a state of euhydration.

Temperature of fluid. Other studies have looked at the temperature of the beverage consumed and whether it allots controlling. A few studies suggest that for palatability a temperature between 15 and 21 degrees Celsius is often preferred, but that this too will vary greatly between individuals (Sawka et al., 2007; Maughan et al., 2005). Similarly in a study performed by Godek, et al. (2004) researchers found football players were less dehydrated when consuming cold water compared to cool to air-temperature water, therefore concluding that cold water should always be available to athletes during practices and competitions. A study by Maughan et al. (2005) was performed on male soccer players practicing in an indoor environment where the temperature of the water was kept cold, but not controlled for, as they stated that it would have "minimal effects" on the outcome of the study in terms of the loss of body weight.

Knowing the vigorous training regimen of UW-Stout track team and the importance of hydration in athletes, one can piece together the important components involved with fluid balance to perceive the necessity of monitoring weight of athletes during practices and/or competitions. On a given day, even a heat acclimated athlete can lose anywhere up to 5% or more of his or her body weight during strenuous exercise (Sawka et al., 2007). It is imperative to realize that each athlete has a different sweat response and will react differently to exercise and hot environments. Two of the simplest methods available to assess hydration status of any athlete include a Ucol test and monitoring weight with a basic scale. When monitoring weight, it is important to make sure weight fluctuations do not exceed a 1% loss and that a proper rehydration protocol is implemented by all coaches and staff (Oppliger & Bartok, 2002).

Chapter III: Methodology

The purpose of this chapter is to describe the subjects that participated in this study, how they were selected and what they were instructed to do. Furthermore, this chapter describes the instruments used, how the instruments were prepared, what the instruments measured and how measurements were made, as well as how the study was designed and constructed. It will also provide the limitations that could have affected the study, as well as how data was analyzed.

Subjects

This study was approved by the University of Wisconsin-Stout Institutional Review Board in November of 2007. Subjects participating in this study were men and women members of the Division III University of Wisconsin-Stout track team in Menomonie, Wisconsin. Participants included both male and female short sprinter runners, quarter-milers and distance runners, as well as female pole-vaulters. Members ranged in age and college level from nineteen-twenty-three years old and freshmen-seniors respectively. The researcher teamed up with coaches to encourage all runners to participate in an effort to obtain the highest number of participants possible for the study. In the beginning of the research process nearly all runners of all events participated, excluding a few injured runners, providing a high number of initial subjects. Participants were not forced to take part in the study and were not given any incentive for doing so. All participants were provided with a list of any possible side effects, risks and/or benefits involved with taking place in this study and then asked to sign a consent form

(See Appendix D) before data collection began. All participants in the sprinting category underwent the same training program and all of the participants in the distance category underwent the same training program. The subject representation was as follows for the participating groups twenty-one sprinter runners (includes short sprints, quarter-milers and pole-vaulters) and thirty-two distance runners.

Instrument

Each subject received a number-coded folder based on a 200-something number for distance runners and a 300-something number for short sprinter runners, quarter-milers and pole-vaulters. The purpose of the number differences was to allow the research to distinguish between distance and sprinter runners for later data analysis. Each folder contained a chart including the date of data collection, weight before practice, weight after practice and the number of water cups consumed (See Appendix E). Numbers were kept confidential from the coaches and the researcher alike, in order to protect the identity of the runners and their weight records. Furthermore, this also allowed the researcher to be removed from the study. The research advisor of the researcher assigned numbers to names of the runners from a roster provided by coaches, and proceeded to email this information to the coaches who initially handed out each respective folder to the respective athlete and then destroyed the information.

The weight of participants was measured using an electronic scale owned by the University of Wisconsin Stout athletic program and located in the training room. The same scale was used consistently from practice to practice and in both the indoor and outdoor seasons. The researcher did not tare the scale daily, as it was an electronic scale and this was not necessary.

Gatorade cups were filled by the researcher prior to each practice to a pre-determined eight-ounce mark and placed out around a water-filled Gatorade cooler. This was done to maintain volume consistency for runners when tallying how many cups of water they consumed. The temperature of the water was kept cold with each cooler containing ice, but was not controlled or kept constant. As previously stated in chapter II some researchers suggest that cooler-temperature water is more appealing to athletes and therefore they will likely consume more, however the temperature of the water and possible variations in the exact temperature would not affect the rate of sweat loss.

Procedures

All participants participated in two data collections, collection A occurred during the indoor track season and collection B occurred during the outdoor season. Collection A consisted of three practices on consecutive Mondays for sprinter runners and consecutive Tuesdays for distance runners. The three Mondays occurred January 28, February 4 and February 11, 2008. The three Tuesdays occurred January 22, January 29, and February 5, 2008. Collection B was originally scheduled to consist of a week worth of practices on consecutive Mondays for sprinter runners and consecutive Tuesdays for distance runners in March 2008. However, due to abnormally long cold and snowy weather conditions, runners were unable to perform outside at these respective times. This resulted in only 12 sprinter runners and no distance runners completing the outdoor season data collection in late April, which did not occur in any consistent, controlled order. Distance runners only practiced outside one time during the forecasted data collection period and did not record any information for this practice therefore no data was obtained for them. All healthy sprinter runners completed the study, however some sprinter runners did not fully complete both seasons due to termination of exercise and injuries.

For collection A, all athletes practiced on the indoor track at University of Wisconsin-Stout for their respective workouts. For collection B, all athletes practiced on the outside track at the University of Wisconsin-Stout for their respective workouts. For both data collections, participants reported to the Athletic training room located in the Health and Fitness building of the UW-Stout Campus at 5:30PM on Mondays and 4:30PM on Tuesdays for data collection A and at 4:00PM and 4:30PM during data collection B. Upon arriving to the scheduled session, each participant weighed his or her self on the electronic scale with males wearing only shorts and females wearing shorts and a sports bra. This pre-practice weight was immediately recorded into the respected chart by the runner and kept blind to the researcher and other runners and coaches. Participants then went about their scheduled practice recording any water they drank throughout this time by tallying the number of previously filled cups they drank onto the provided chart (see Appendix F). From this chart he or she could later copy the total number of cups consumed into the respective folder. The researcher was not present during practice sessions to ensure encouraging or discouraging of water intake did not transpire. Immediately following the practice sessions, participants were instructed to towel off any excess sweat, remove any sweat soaked clothing or change and report back to the weigh in area to again weigh in wearing the amount of clothing previously stated. He or she then recorded the post-practice weight in the table next to pre-practice weights and handed his or her folder in to the respective coach, who kept them in a secure binder locked in his office until the next data collection. It is important to note that salt intake of runners was not controlled for in this study and the researcher relied on player's knowledge and honesty to consume salt. Water was not measured all day for these athletes, but rather only during the time of track practice.

Calculations

For the purpose of this study sixteen-ounces of fluid were considered equal to a one-pound weight loss (IDEA, 2005). The researcher corrected each and every folder based on the amount of water consumed by the athletes during practice to obtain their "new" post-exercise weight depending on the ounces ingested. This "corrected" number was then subtracted from the pre-exercise weight in order to determine the total number of pounds lost by each individual athlete. As explained in chapter II, the equation of weight lost during exercise (ounces) + fluid consumed during exercise (ounces) is equal to the amount of water players are suggested to then consume during exercise to insure proper replacement of sweat losses, which will be recommended based on the group average in chapter V.

Data Analysis

The purpose of this data analysis is to first analyze the mean sweat losses incurred by both distance and sprinter runners during the indoor season as well as for those sprinter runners who completed the outdoor season. Data will be tested for normality of distribution and will provide illustrate means, minimums and maximums, skewness and kurtosis for the following measurements; pre- and post-exercise weight, mean weight loss, mean percentage of weight loss and water consumed. Data will be presented in the text as a mean +/- the standard deviation or *n* (SD = #), with the ranges (minimum and maximum) following in parentheses. This information will allow the researcher to look at the differences between distance runners and sprinter runners as well as the difference among sprinter runners incurred between the two environments.

Next, this data analysis will test the significance of the measured changes in percentage of body weight lost for distance and sprinter runners during the indoor season, as well as for those sprinter runners who completed the outdoor season. A one-sample t-test will be performed to compare the average percentage of weight lost to the statistic of 1.5%, which was previously stated as a significant percentage of body weight loss for this study.

Then, a paired samples t-test will be used to determine if there is a statistically significant difference in the amount of weight lost when compared to the amount of fluid consumed. This test will be performed only on sprinter runners, but will be performed separately for the indoor and outdoor season. Distance runners did not consume any fluid during the indoor environment, which they completed, so no tests were run on their data.

Correlations will also be run on the data to determine if a statistically significant positive or negative relationship exists between the amount of weight lost and the amount of water consumed. Once again, these will only be performed on sprinter runners and will be performed separately for the indoor season and the outdoor season as well. Likewise, a correlation will be performed to determine if there is a relationship between the amount of weight lost during the indoor season and the amount of weight lost during the outdoor season for the sprinter runners. For these tests, a p-value of less than 0.05 or 0.001 will be used to determine statistical significance and will be reported with the respective data.

Finally, an independent sample t-test will be performed in order to compare the percentage of weight lost during the indoor season for distance and sprinter runners. This will allow the researcher to determine if one of the two groups of runners is losing a statistically significant greater percentage of weight during indoor training.

Furthermore, graphs will then be constructed to offer a visualization of any potential correlations in fluid loss indoors versus fluids loss outdoors, as well as water consumed and sweat (weight) lost during the indoor environment and during the outdoor environment.

The first goal of this study is to determine if significant water losses are being experienced in the runners during their indoor and/or outdoor environments. Another goal of this data analysis is to determine if indoor environments pose similar, greater or lesser water losses than outdoor environments in runners. A third goal of this data analysis is to provide information about the seldom-studied indoor exercise environment and related water losses, as well as the amount of fluid taken in during these exercise bouts. Furthermore, to be able to apply this knowledge in a real sports environment for other Division III indoor and outdoor track teams to use in their training programs.

Limitations

As with most research, there are some limitations to this study. First, it is possible that the scale could pose some inconsistency, questioning the reliability of runner's weights, as it could vary slightly from day to day or even hour to hour. Unfortunately, there is no way to control for such variances, as the scale is electronic, possibly negatively influencing the study.

A second possible limitation is that water and salt ingested during the day and directly before practices was not taken into consideration in this study. This could have affected the weight of runners, especially if water was ingested directly before weighing runners or if the runners forgot to void before weighing. Studies also show that salt intake can affect hydration status differently depending on if too much, too little or just enough is ingested (Hsieh, 2004; Rehrer, 2001; Sawka et al., 2007). All subjects were asked to void before practice, but if they failed to do so and voided during practice, this would also affect results.

Another limitation may have occurred by having water cups pre-measured and filled in an effort to ensure all runners would grab the designated 8 ounces consistently. This may have encouraged athletes to drink more than normal because the cups were already prepared and easily accessible to grab and consume as opposed to usually having to take time to fill them at one's own desire.

Furthermore, during this particular spring in Wisconsin, the weather did not present optimal conditions for data collection. This resulted in the inability to collect some data, therefore lowering the number of completing participants and eliminating a whole group. Also, these cooler-than-normal conditions could present different results than would an average, warmer spring.

Finally, many dropouts occurred in this study both due to injury and the fact that not all were able to practice outdoors for the time period in which outdoor data was collected. This severely hindered the research study and will greatly affect the results and averages.

Chapter IV: Results

This chapter will include the results obtained during the study including results from the statistical analysis of both the distance and sprinter runners. The latter portion of this chapter will summarize the findings based on the research objectives for the proposed study.

Item Analysis

In January of 2008, thirty-two distance and twenty-one sprinter runners from the University of Wisconsin Stout track team in Menomonie, Wisconsin volunteered to partake in this research study. Each participant signed an informed consent, previously approved by the University of Wisconsin Stout research committee. The first set of data collections occurred on the indoor track in the Multi-purpose room of the Howard Johnson Field House on the University of Wisconsin Stout campus. This data collection consisted of three separate practice days for the distance runners and three separate practice days for the sprinter runners. The potential number of participants from these two groups totaled a participation of fifty-three runners (n=53) total subjects in this study. Sixteen distance and nineteen sprinter runners completed the first portion of data collection in January of 2008 and were scheduled to participate in a second data collection to occur in April of 2008. In April of 2008 zero distance runners and twelve sprinter runners returned to complete the second set of data collections. This collection occurred on the outdoor track across the street from the Howard Johnson Field House on the University of Wisconsin Stout campus and consisted of three separate practice days. The charts used to collect the data for both the sprinter and the distance runners during both data collections can be seen in Appendix E.

Statistical Analysis

The data were tested for normality of distribution and can be seen presented in the following results paragraphs as a mean with +/- the standard deviation with the ranges following in parentheses. The skewness and kurtosis of the variables were also obtained and can be seen below in Table 1. One sample t-tests were used to analyze the statistical significance of the percentage of body weight lost during training compared to the standard statistic of 1.5% mentioned in chapter II. This test was performed on distance runners for the indoor season and on sprinter runners for both indoor and outdoor seasons. Statistical significance of the measured changes in body mass for both the indoor and outdoor training was assessed separately using a paired t-test for each season independently of each other. Pearson correlations between the two training environments were performed, as well as a Pearson correlation between the average body-weight lost in each independent environment and the respective water consumed for that environment. Two-tailed, a p-value of less than 0.05 was used to determine statistical significance for all tests. Finally an independent sample t-test was run to determine if statistically significant differences were present between the percentage of weight loss for distance runners and the percentage of weight loss for sprinter runners during the indoor season.

Results

Distance runners

Indoor season. Descriptive statistics were run on all indoor data for the distance runners in order to obtain the following data. The average pre-training body weight of distance runners during the indoor season was 141.8 pounds (SD = 14.60l) with ranges from 119.3-164.7 pounds. All athletes lost weight during the indoor season training sessions. The average body weight after training during the indoor season for the distance runners was 139.1 pounds (SD = 14.14) with ranges from 117.6-161.7 pounds. Average weight lost during the indoor season for distance runners was 2.73 pounds (SD = 0.96) with ranges from 1.5-4.6 pounds. This is equivalent to a dehydration rate of 1.90 % (SD = 0.59) with ranges from 0.9-2.9% of pre-training body weight lost during the indoor season for distance runners. Considering, as aforementioned, a weight loss of 1.5% of pre-training body mass to be significant, there was a statically significant weight loss over the indoor training session for distance runners, as on average, a 1.9% of body mass was lost.

A one sample t-test was performed to analyze the statistical significance of the percentage of pre-training body mass lost during the indoor training for the distance runners. It was compared to a statistic of 1.5% being considered significant, as was explained in further depth in Chapter II. This test reported that a significant percentage of mass loss was seen in the distance runners during their indoor training sessions, $t(15) = 2.69, p > .05$.

No data was obtained for distance runners during the outdoor season due to unfavorable weather conditions.

Sprinter runners

Indoor season. Descriptive statistics were run on all indoor data for the sprinter runners in order to obtain the following results. The average pre-training body weight of sprinter runners during the indoor season was 152.94 pounds (SD = 21.43) with ranges from 115.9-204.3 pounds. All athletes lost weight during the indoor season training sessions. Body weight after training during the indoor season for the sprinter runners was

151.27 pounds (SD = 21.25) with ranges from 114.8-202.4 pounds. Average weight lost, in pounds, during the indoor season for sprinter runners was 1.7 pounds (SD = 0.50) with ranges of 1.0-2.6 pounds. This is equivalent to a dehydration rate of 1.08% (SD = 0.30) with ranges from 0.7-1.6% of pre-training body mass lost during the indoor season for sprinter runners. Considering a weight loss of 1.5% of pre-training body weight to be significant, there was a considerable, but not a statistically significant body mass loss over the indoor training session for sprinter runners.

A one-sample t-test was run on the data to test the statistical significance of the percentage of pre-training body weight during their indoor season. Results showed no statistical significance was seen in the percentage of body mass lost during training in the indoor season for the distance runners. The percentage of dehydration experienced during the indoor season is just above that which is considered to be the level at which thirst is first perceived (1%) and is therefore considerable, but not statistically significant. Please refer to Table 2 for a complete report of statistical values.

Mean fluid intake during indoor training was 14.73 ounces (SD = 11.05) or 1.10 pounds (SD = 0.64) with ranges from 0.0-36.0 ounces consumed. There was a statistically significant difference seen between the amount of weight lost during the indoor season and the amount of water consumed during the indoor season for sprinter runners. Average weight lost was 1.7 pounds (SD = 0.5) and average water consumed was 1.10 pounds (SD = 0.6). A paired samples t-test was used to determine if there was a statistical difference in the amount of weight lost during the indoor season versus the amount of water consumed during the indoor season. Table 2 shows that indoor sprinter runners had a statistically significantly higher weight loss than water intake in pounds, with an average difference of 0.56 pounds.

A correlation was run to determine if there was a relationship between weight lost and water consumed during the indoor season. There was an apparent, statistically significant positive correlation between the extent of sweat loss and the volume of fluid consumed during indoor training. Those who lost the most weight during the indoor season were also found to consume more water during the indoor season. This relationship is illustrated below in Figure 1 and a complete report of statistical values can be found in Table 3.

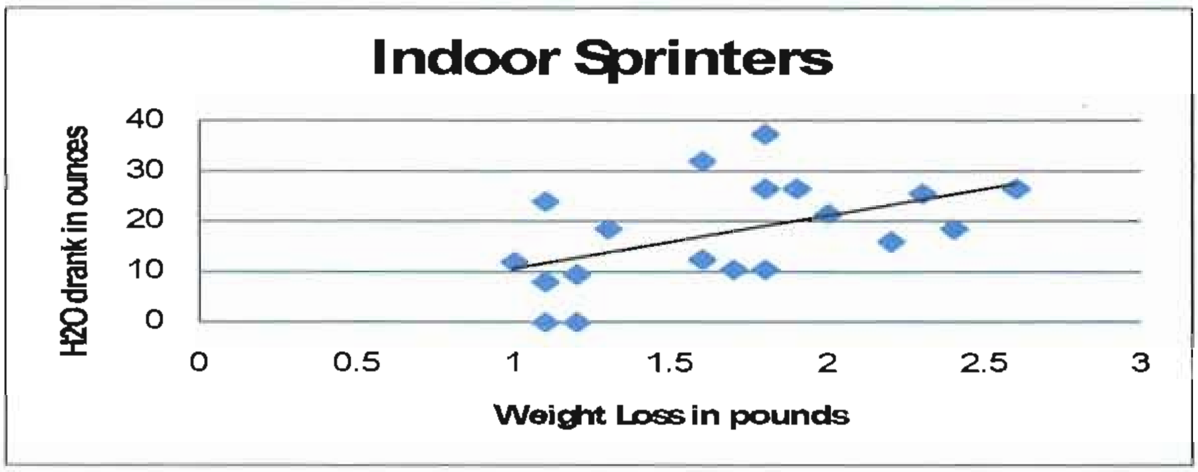

Figure 1. Correlation between the amount of water consumed during the outdoor season and the amount of weight lost in pounds for sprinter runners completing both seasons.

Outdoor season. Descriptive statistics were run on all outdoor data for the sprinter runners in order to obtain the following results. The average pre-training body weight of the sprinter runners during the outdoor season was 147.86 pounds (SD = 18.79) with ranges from 114.1-176.6 pounds. All athletes also lost weight during the outdoor season training sessions. Body mass after training in the outdoor season was 146.57 pounds (SD = 18.62) with range s from113.3-175.4 pounds. Average weight lost, in pounds, during the outdoor season was 1.28 pounds (SD = 0.61) with ranges from 0.5-2.5 pounds. This is equivalent to a dehydration rate of 0.86 pounds (SD = 0.38) with ranges from 0.4-1.6% of pre-training body mass during the outdoor season. Once again considering a weight loss of 1.5% of pre-training body weight to be significant, there was a considerable, but not a statistically significant body mass loss over the outdoor training sessions.

A one-sample t-test was run on the data to test the significance of the percentage of pre-training body weight during their outdoor season. Results revealed no statistical significance was seen in the percentage of body mass lost during training in the outdoor season for the distance runners. The percentage of dehydration experienced during the outdoor season is below that which is considered to be the level at which thirst is first perceived (1%) and therefore not as considerable nor statistically significant. Please refer to Table 2 for a complete report of statistical values.

Mean fluid intake during outdoor training was 7.17 ounces (SD = 6.37) or 0.45 pounds (SD = 0.40) with ranges from 0.0-22.0 ounces consumed. There was a statistically significant difference seen between the amount of weight lost during the outdoor season versus the amount of water drank during the outdoor season for sprinter runners. Average weight lost was 1.3 pounds (SD = 0.6) pounds and average water consumed was 0.45 pounds (SD = 0.40). A paired samples t-test was used to determine if there was a statistical difference in the amount of weight lost. Table 2 shows that outdoor sprinter runners had significantly higher weight loss than water intake in pounds; the average difference in weight lost and water consumed was 0.84 pounds during the outdoor season.

A correlation was run to determine if there was a relationship between weight lost and water consumed during the outdoor season. There was an apparent, statistically significant positive correlation between the extent of sweat loss and the volume of fluid consumed during outdoor training. Those who lost the most weight during the outdoor season were also found to consume more water during the outdoor season. This relationship is illustrated below in Figure 2 and a complete report of statistical values can be found in Table 3.

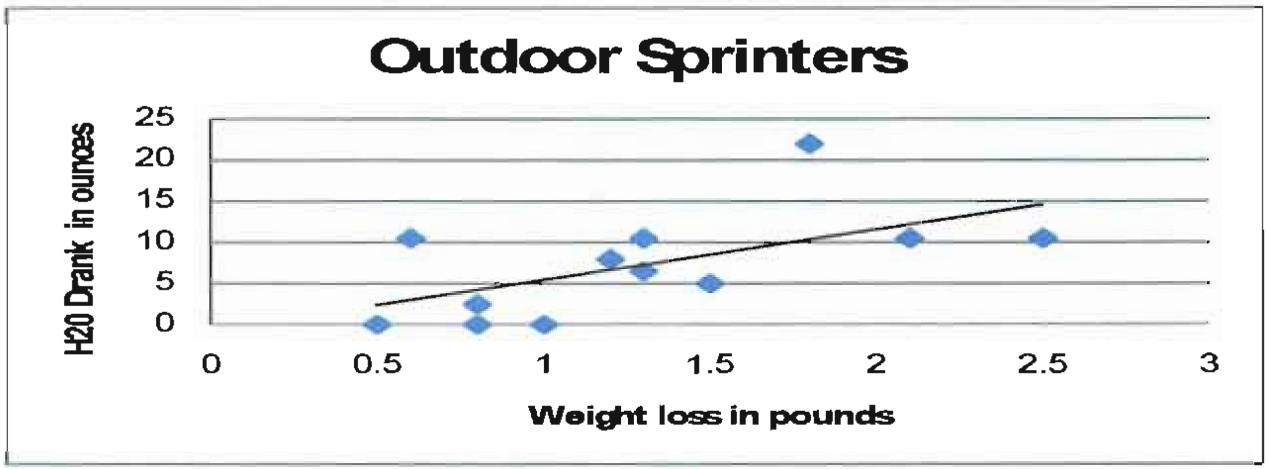

Figure 2. Correlation between the amount of water consumed during the outdoor season and the amount of weight lost in pounds for sprinter runners completing both seasons.

Indoor season vs. outdoor season. There was a statistically significant difference between the body mass lost, in pounds, indoors and the body mass lost outdoors. A paired samples t-test was used to compare the indoor season to the outdoor season in terms of the weight lost for the sprinter runners in both seasons. During the indoor season, sprinter runners had a statistically significant higher weight loss (1.6 +/- 0.5 pounds) than during the outdoor season (1.3+/- 0.6 pounds) with an average difference of 0.34 pounds. Please refer to Table 2 for a complete report of statistical values.

A statistically significant difference was also seen between the percentage of body mass lost during the indoor season and the outdoor season. A paired samples t-test was used to compare the indoor season to the outdoor season in terms of the percentage of body mass lost for the sprinter runners in both seasons. During the indoor season sprinter runners had a statistically significant higher percent of body mass loss (1.08 +/- 0.35%) than during the outdoor season (0.86 +/- 0.38%) with an average difference of 0.23%. Please refer to Table 2 for a complete report of statistical values.

A paired samples t-test revealed a statistically significant difference was seen between the amount of water consumed during the indoor season and the amount of water consumed during the outdoor season, with the indoor season having a higher average consumption of 7.6 ounces. Please refer to Table 2 for a complete report of statistical values.

Statistically significant fluid losses were found neither in the indoor season nor the outdoor season. A one-sample t-test was used to compare the percent of weight loss and test it against the standard value of 1.5 (as 1.5% was used for this study to be considered significant). Statistically, neither indoor nor outdoor sprinter runners had a fluid loss of 1.5% or greater, therefore significance was not obtained. Please refer to Table 2 for a complete report of statistical values.

A correlation was used to determine if there was a relationship between the body mass lost during the indoor season and the body mass lost during the outdoor season for individual sprinter runners. As illustrated in Figure 3 below, there was an apparent, statistically significant positive correlation between body mass lost indoors and body mass lost outdoors. Those individuals who were found to have lost the most weight during the indoor season were also found to have lost the most weight during the outdoor season. Please refer to Table 3 for all complete report of statistical values.

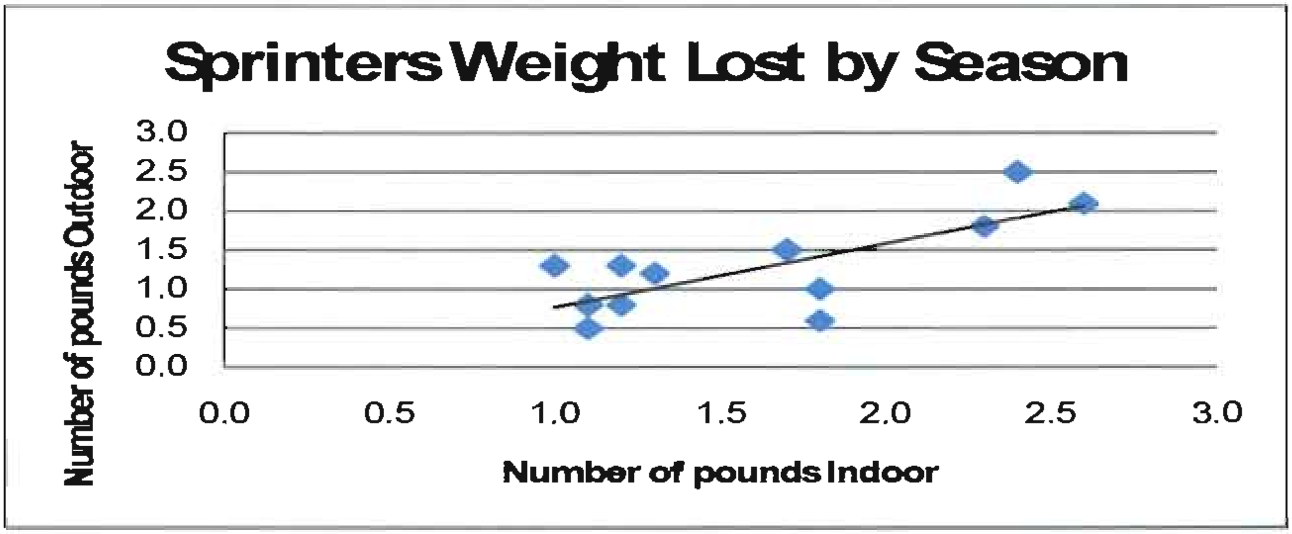

Figure 3. Correlation between individual sprinter runner's weight loss during the outdoor season and individual sprinter runner's weight loss during the indoor season.

Distance compared to sprinter runners

Indoor season. No distance runners completed the outdoor season, but the following will compare the distance runners to the sprinter runners during the indoor season in terms of weight loss and percentage of weight loss. For the weight lost during the indoor season, distance runners (n=16) had a mean weight loss of 2.73 pounds (SD = 0.96), where as sprinter runners (n=19) had a mean weight loss of 1.67 pounds (SD = 0.49). In terms of percentage of body mass lost, distance runners had a mean percentage weight loss of 1.90% (SD = 0.59), where as sprinter runners had a mean percentage weight loss of 1.08% (SD = 0.30). This data shows that during the indoor track season, distance runners, on average, had higher sweat losses and percentage of sweat losses than did their sprinter counterparts. Although no data was obtained for distance runners during the outdoor season, further research could be done to obtain this information and compare their outdoor losses as well, as was the original intent of this study.

An independent sample t-test was run on the distance and sprinter runner's weight lost and percentage of weight lost for the indoor season. This test revealed that there was a statistically significant difference in both the amount of weight was lost and the percentage of body mass lost between distance runners and sprinter runners. In terms of weight lost distance runners lost, on average, a statistically significant higher amount of weight than did the sprinter runners by an average of 1.06 pounds (SD = 0.25). Likewise, distance runners lost a statistically higher percentage of weight loss, on average, than did their sprinter runner counterparts by an average of 0.82% (SD = 0.16). Please refer to Table 4 for a complete report of statistical values.

Table 1

Descriptive statistics not included in text for sprinter runners during Indoor & Outdoor Seasons

	Skewness Statistic	Skewness Std. Error	Kurtosis Statistic	Kurtosis Std. Error
Indoor				
Pre-weight	0.24	0.52	0.60	1.01
Post-weight	0.26	0.52	0.63	1.01
Weight lost	0.29	0.52	-0.96	1.01
Percent weight lost	0.53	0.52	-0.65	1.01
Water drank in ounces	-0.01	0.52	-0.55	1.01
Outdoor				
Pre-weight	-0.41	0.64	-0.68	1.23
Post-weight	-0.38	0.64	-0.69	1.23
Weight lost	0.69	0.64	-0.15	1.23
Percent weight lost	0.61	0.64	-0.52	1.23
Water drank in ounces	0.93	0.64	1.46	1.23

Table 2

Paired Sample t-tests & One-Sample Statistics for sprinter runners indoors and outdoors

Comparison	t-value	df	p-value	Mean difference
Indoor vs. outdoor wt. loss	2.81	11	0.02*	0.34
Indoor vs. outdoor % wt loss	2.79	11	0.18*	0.22
Indoor vs. outdoor water drank	2.49	11	0.03*	7.57
Indoor wt loss vs. water drank	4.27	18	0.00*	0.56
Outdoor wt loss vs. water drank	5.83	11	0.00*	0.84

* Paired Sample Statistics were run to obtain values at a significance level of $p<0.05$
**One Sample Statistics were run to obtain these values at a significance level of $p<0.05$

Table 3

Correlation Values for sprinter runners during both indoor and outdoor seasons

Correlation	Correlation Value
Indoor wt loss vs. water drank	0.51*
Outdoor wt loss vs. water drank	0.59*
Indoor wt loss vs. outdoor wt loss	0.75**
Indoor water drank vs. outdoor water drank	

*All significance was tested at a level of $p<0.05$ for these tests
** All significance was tested at a level of $p<0.001$ for these tests

Table 4

Independent Sample t-test for equality of means for weight loss & percentage weight loss comparing distance and sprinter runners during the indoor season

	t-value	df	Sig. (2 tailed)	Mean difference	Std. error difference
Weight lost	-3.99	21.41	0.00	-1.06	0.25
Percent lost	-5.02	21.28	0.00	-0.82	0.16

All significance was tested at a level of $p<0.05$ for this test

Despite the fact that no data could be obtained for distance runners during the outdoor season, significant findings were obtained for these athletes during the indoor season. For the distance runners, statistical significance was found in the amount of body weight lost during practice in the indoor season, as well as the percentage of body mass lost. For all runners, a percent body mass loss of 1.5% of pre-training body weight was considered to be a significant weight loss, based on previous research and standards. For the distance runners, an overall significance was seen in body weight percentage during their indoor season, as the average percent body mass loss was 1.9 +/- 0.59%. Therefore, distance runners are well over what professionals consider a significant percent body mass loss and are close to the 2% statistic, said to be the point where athletes begin to see decreases in performance levels. Therefore, it is important that these distance athletes and their coaches alike recognize and monitor their weight losses and drinking habits during indoor season practices. The study also found that distance athletes were not drinking water throughout practices, which likely plays a large factor in this great reduction in body mass during practice sessions.

For the sprinter athletes, although all of the athletes lost weight in both of their respective seasons (indoor and outdoor), there was not a statistically significant percentage of body mass lost in either environment. During the indoor season, sprinter athletes lost an average of 1.08 % of pre-training body mass. Sprinter athletes drank, on average, 14.73 ounces of water during their indoor season practice sessions. This is an encouraging finding, as it is recommended that athletes consume 7-10 ounces of fluid every fifteen minutes during exercise to offset any losses through sweat, which would equate to 28-40 ounces in an hour practice (IDEA, 2005). This statistic shows that although sprinter runners are not quite at their ideal consumption yet, they are well on their way. During the outdoor season, sprinter athletes lost an average of 0.86 % of pre-training body weight, which is even lower than those experienced during the indoor season. On average, sprinter athletes drank 7.17 ounces of water during their outdoor season.

Based on these findings, a paired comparison revealed a statistically significant difference between the amount of weight and the percentage of body mass lost in the indoor season versus the outdoor season. The indoor season elicited statistically significant higher losses in both the weight and the percentage of weight in the sprinter athletes compared to the outdoor season. A paired comparison also revealed a statistically significant higher amount of water was consumed during the indoor season than was consumed during the outdoor season in sprinter athletes.

Positive correlations were seen between the amount of water consumed during the indoor season and the amount of weight lost during the indoor season, with those losing the most weight also being those who consumed the most water. Similarly, a positive correlation was seen in the amount of water consumed during the outdoor season and the amount of weight lost during the outdoor season. Once again, those who lost the most weight during the outdoor season were also the ones to consume the most water during the outdoor season. Lastly, a positive correlation was seen between the amount of water lost during the indoor season and the amount of water lost during the outdoor season, with those who lost the most weight in the indoor season also being the ones to lose the most weight in the outdoor season.

The following and final chapter will look at the results explained above and compare them to what was hypothesized in chapter I. It will serve to explain any possible discrepancies in what was found and what was expected to occur, as well as touch on any findings that supported what was predicted. Finally, it will serve to give insight into possible topics that could be covered in future research and any areas that require further research to be performed before making any final conclusions.

Chapter V: Discussion

Chapter V compares and discusses the data collection and its respective relation to other pertinent findings. Recommendations for further research and ways to help minimize the amount of water lost by athletes will conclude this chapter.

Limitations

One of the major limitations during data collection included the unusual weather patterns that occurred in Wisconsin during the spring 2008 outdoor track season. Due to the unusually long winter-like conditions and long lasting snow, athletes were unable to practice outside until the very end of the season, which resulted in the inability to collect data for the distance runners during this portion of the study. During a normal spring, athletes practice outside beginning in the middle-end of March until early May. However, during this particular season, athletes could only practice outside on sporadic days leading my data collection to occur random April evenings, rather than 3 consecutive scheduled practices as planned. Furthermore, the weather during this time was not as warm as it has been in past years with the highest temperature reaching only 65 degrees Celsius, whereas in previous years highs have been in the high 70s to low 80s. This could have affected not only the sweat rates seen in athletes during this season, but also the amount of water the athletes felt like consuming during practice.

Conclusions

Distance runners. On average, distance runners lost an overall body weight of 2.7 +/- 0.96 pounds while practicing on the indoor track at the University of Wisconsin Stout. Statistical tests revealed this weight loss was statistically significant, suggesting that distance runners did indeed lose substantial weight during the indoor season. The amount of weight lost resulted in an average weight loss percentage of 1.90 +/- 0.59% after calculations were performed by dividing post-exercise weight by pre-exercise weight, as described in chapter III. As mentioned in chapter II, a percentage weight loss of 1-2% of pre-exercise body mass is considered to be a mildly significant amount of weight loss in regards to the dehydration of body fluid. For the purpose of this study a 1.5% weight loss of pre-exercise body mass was considered statistically significant, as thirst is experienced at the 1% dehydration level and 2% is said to be when declining performance is seen. Comparing the distance runners average percentage weight loss of 1.9% to the 1.5% statistic, statistical significance was obtained. From these tests the researcher can conclude that during the indoor season, the distance runners are in fact losing a statistically significant percentage of their body mass and fluid replacement should be highly encouraged.

The amount of water consumed by the distance runners is significant in the fact that none of them recorded drinking any water during the indoor season. Not only is this a problem, but it is likely a great contributing factor to the large amount of weight lost during the indoor season and the statistical significance of the percentage body mass lost. Water intake is accounted for in the equation used to find the percentage of weight lost during exercise. It is important to note that for athletes not taking in water, higher percentages of body mass loss become even more critical. This really means the amount of weight they are losing due to sweat is not being replaced with fluids, therefore increasing the risk of dehydration. Furthermore, the chance of these athletes experiencing declines in performance is greater as well recalling that body mass loss of as little as 2% can cause performance declination when body fluid is not replaced.

Although no data was obtained for distance runners during the outdoor practice season, it may be suggested that theses runners are likely to consume little-to-no water during the outdoor season as well. Water is not readily available to distance runners during long outdoor runs, as they generally run off campus. During indoor data collection all distance runners practiced on the indoor track where ready-to-drink water was set up for them. According to the runners and the water tallies however, they didn't choose to consume water even in this situation. It is likely then, that when water is less available while running in various places during the outdoor season that they would not stop to consume water where and if it is available. It is also unlikely that they would carry water with them on their run. This would mean that during the outdoor season, distance runners are likely to become dehydrated during practices at levels comparable to or greater than the indoor season. More research would be beneficial in this area to study the behavior of distance runners and the rate of body mass lost during the outdoor season, but I tend to think that significant losses would be seen in this environment as well.

Sprinter runners. On average, sprinter runners lost an overall body weight of 1.7 +/- 0.50 pounds while practicing on the indoor track at the University of Wisconsin Stout. Statistical tests revealed this weight loss was not statistically significant, suggesting that sprinter runners did not lose substantial weight during the indoor season. The amount of weight lost resulted in an average weight loss percentage of 1.08 +/- 0.30% after calculations were performed by dividing post-exercise weight by pre-exercise weight, as described earlier. As mentioned in the distance section, for the purpose of this study a 1.5% weight loss of pre-exercise body mass was considered to be statistically significant. Comparing the sprinter runners average percentage weight loss of 1.08% to the 1.5%

statistic, statistical significance was not obtained for these athletes. From these tests the researcher can conclude that during the indoor season, some sprinter runners are losing a good percentage of their body mass during exercise, meaning fluid replacement should still be encouraged, however their weight loss is not statistically significant. To see individual losses and variance in individual rates, please refer to Appendix I.

On average, sprinter runners lost an overall body weight of 1.28 +/- 0.61 pounds while practicing on the outdoor track at the University of Wisconsin Stout. This quantity of weight loss was even lesser than that of the weight lost during the indoor season, discussed in the previous paragraph, which will be further compared and discussed later in the chapter. Statistical tests revealed this weight loss was not statistically significant, suggesting that sprinter runners did not lose substantial weight during the outdoor season. The amount of weight lost resulted in an average weight loss percentage of 0.86 +/- 0.38% after calculations were performed by dividing post-exercise weight by pre-exercise weight, as discussed earlier. As mentioned above, for the purpose of this study a 1.5% weight loss of pre-exercise body mass was considered to be statistically significant. Comparing the sprinter runners average percentage weight loss of 0.86% to the 1.5% statistic, statistical significance was not obtained for these athletes. From these tests the researcher can conclude that during the outdoor season, some sprinter runners are losing a good percentage of body mass during exercise, so fluid replacement should still be encouraged, however their weight loss is not statistically significant.

In a comparison of the average body mass lost during the indoor season and the outdoor season, statistical testing revealed a statistically significant difference between the two averages. Paired sample t-tests run on both the body weight lost and the percent body mass lost show a statistically significant higher percentage of weight loss during the indoor season than during the outdoor season. This is surprising for a couple of reasons when considering what previous research has found. First, researchers hypothesize that as an athlete is acclimatized, or better conditioned, they are likely to experience a greater sweat rate than when they first initiated exercise, or more than someone who is just starting to exercise (Cheung & McLellan, 1998; Neilsen et al., 1993). This same study does state, however, that fit individuals appear to have a more rapid adaptation to heat exposure than those who are not fit. Second, previous studies performed on athletes exercising in a variety of environments have stated that higher sweat rates are seen as core temperature rises with increased heat and varying environmental conditions, likely in an effort to cool the body (Nielsen et al., 1993; Godek et al., 2004; Sawka et al., 2007). This being said, it is surprising that greater sweat loss was not seen in these athletes after adding sunshine, warmer temperature and varying wind speeds into the practice environment.

The average difference of percent body mass loss between the seasons (1.08 +/- 0.35%) could be due to a variety of factors present during data collection. First of all, it is possible that exercising in an indoor environment may provide a dry climate during winter months in the Northern region of the United States. A dry environment may cause the body to dry out as well, resulting in a loss of overall body water. A reduction in body water could result in consequences such as less water available to circulate to organs and muscles, a dry throat, dry cracking skin, a greater sensation of thirst and possibly even affect performance. Second, it is possible that the unusual spring months of 2008 in Northern Wisconsin and cooler temperatures during the outdoor season affected sprinter runners different than it normally would. Although all days of outdoor data collection were sunny, it is possible that due to the lower-than-normal temperatures experienced, athletes were not experiencing a normal levels of exertion. This could, in turn, cause less sweat to be produced and lower the perceived sensation of thirst. If warmer temperatures would have ensued, it is possible that the body temperature of athletes may have increased; causing both greater sweat-production and water consumption. Third, it is possible that athletes were better trained and therefore more acclimatized to exercise by the time the second data collection occurred. Although runners are encouraged to stay in shape year round, it is not mandatory, nor monitored by coaches. By the time the outdoor data collection occurred, it is possible that the athletes were more-fit and therefore, as described above, better able to adapt to the surrounding environment. One piece of contradicting information in this theory is that a fit individual is also said to sweat sooner and more than a less-fit counterpart. In this scenario, you would expect a person to experience an overall greater loss of body weight during the outdoor season when athletes are already in shape from their outdoor season. Based on this theory then, they would be sweating more and longer than during their indoor season because they are more fit now than when they began. Whatever the reason may be, it is clear from this study that sprinter runners experienced higher water losses during the indoor season than during the outdoor season of their training.

On average the amount of water consumed by the sprinter runners is better than that of the distance runners, in that sprinter runners did in fact consume water during both practice settings. The average amount of water consumed by the sprinter runners was 14.73 +/- 11.05 ounces during their indoor season, which was compared to the amount of weight lost during the indoor season to test for significance. The paired samples t-test revealed statistical significance between the amount of weight lost during the indoor season and the amount of water consumed during the indoor season. Testing showed that sprinter runners experienced a statistically significant higher weight loss than water intake, in pounds, with an average difference of 0.56 pounds. This relationship could be related to the dry, indoor environment explained earlier causing runners to experience more exasperated symptoms of an overall dryness within the body. It is also possible that sprinter runners were in a state of good acclimatization to the indoor environment, as practice had been going on for around two months at the time of data collection. Previous research hypothesizes that a seasoned individual is going to sweat earlier and more than an unseasoned athlete, so it is possible that these athletes were well-fit and therefore experiencing higher fluid loss and lower thirst sensation.

Although the amount of water consumed during the outdoor season was lower than that during the indoor season, it was still encouraging to see that sprinter runners were making an effort to consume water during practice. On average amount of water consumed by the sprinter runners was 0.45 +/- 0.40 ounces during their outdoor season, which was compared to the amount of weight lost during the outdoor season to test for significance. The paired samples t-test again revealed statistical significance between the amount of weight lost during the outdoor season and the amount of water consumed during the outdoor season. Testing showed that sprinter runners experienced a statistically significant higher weight loss than water intake, in pounds, with an average difference of 0.84 pounds. This greater level of weight loss compared to water intake could be due to a few different factors. First, as stated in the indoor season, it is possible that sprinter runners were in a state of good acclimatization and very fit at the time of data collection, as they were nearing the end of their season. Once again, a seasoned athlete may sweat earlier and more than an unseasoned athlete, possibly leading to high fluid losses and a lower thirst sensation. Also, although we didn't find the level of weight loss that was expected in an outdoor environment, it is likely that the presence of the sun and wind played a factor in causing high sweat rates. Yet, since the environment was not dry, as it was indoors, the sensation of thirst may not have been as great as it was indoors, resulting in less fluid consumption. This would explain the statistically significant higher loss of body mass than water intake in this particular environment. Whatever the reason, an even greater difference of weight lost compared to water consumed, in pounds, was found during the outdoor season than during the indoor season.

Even though sprinter runners consumed water during both their indoor and outdoor seasons, the amount consumed is likely a contributing factor to the weight lost and the significance of percent body mass lost in these seasons. Water intake is accounted for in the equation used to find the percentage of weight lost during exercise, but if an athlete does not take in enough water, higher percentages of weight loss may be seen. This is simply because the amount of weight they are losing due to sweat is not being completely replaced with fluids, therefore increasing the risk of dehydration. Furthermore, the chance that athletes will experience performance declination is still a concern when considering a 2% loss of body mass can have this affect when fluid placement is absent. It is important to look at the raw data for sprinter runners to assess the varying levels of sweat experienced by individual runners. While some runners did not lose a lot of weight, others did and it is important for those individuals to know and recognize their level of sweat loss, in order to correctly replace it.

Performing a correlation on different aspects of the results led to some interesting findings in the data. One such correlation was run to determine if a relationship existed between the body mass lost during the indoor season and the body mass lost during the outdoor season. This test revealed that there was a statistically significant, positive correlation between the body mass lost indoors and the body mass lost outdoors. Those sprinter runners that lost the most weight during the indoor season were interestingly those who lost the most weight during the outdoor season as well. This information is useful to both the individual runners and coaches, as it will provide insight as to those who have a tendency to sweat more. Therefore, athletes can be more attentive to replacing their losses and coaches can encourage more frequent breaks. It is still important for low sweating individuals to drink during practice, but it is even more critical for someone losing a lot of fluid to consume enough water to offset any major fluid loss. This information could possibly help heavy sweating individuals avoid injuries and declines in performances. Knowing one is susceptible to lose more fluid, he or she can be more attentive to the amount of water and electrolytes consumed from day-to-day.

A correlation was also performed to determine if there was a relationship between weight lost and water consumed during the outdoor season. Results revealed a statistically significant, positive correlation between the extent of sweat loss and the volume of fluid consumed during outdoor training. This meant that the sprinter runners that lost the most weight during the indoor season also consumed the most water during the outdoor season.

One final correlation was performed to determine if there was a relationship between weight lost and water consumed during the indoor season. Once again, there was a statistically significant positive correlation between the extent of sweat loss and the volume of fluid consumed during indoor training as well. That meant that those who lost the most weight during the indoor season were also consuming the most water during this time.

These statistics are interesting, in that they may suggest those who are sweating the most are in fact experiencing an increase in perceived thirst. Studies have stated that thirst is sensed at a dehydration level of 1% of pre-training body mass and this study may in fact support these findings. When looking at the raw data provided for each individual and comparing percentage of body weight loss to the amount of water consumed, it was appeared to be factual within this study. It was not surprising to find this correlation within the study, though it was exciting to have this current study reveal similar results as previous research. One possible explanation could be that the athletes sweating at a higher rate could be the ones who have been running for a longer amount of time and are more in-tune with their body. Not only do studies suggest that athletes of a higher fitness level sweat more, but it is possible that with experience, athletes know they need to take in more water when sweating at higher rates. This study may imply that these athletes are indeed listening to their bodily response to exercise of knowing when it needs replenishing. The body is an amazing machine that can sense many things and it is remarkable to see it signaling an increased need for water to maintain proper function with exercise.

Distance runners vs. sprinter runners. Although no distance runners completed the outdoor season, statistical tests were still performed to compare indoor season average weight and percent body mass losses to those of the sprinter runners. On average, distance runners experienced a statistically significant higher weight loss than their sprinter counterparts by an average of 1.06 pounds during the indoor season. Likewise, a statistically significant higher percent body mass loss was seen in distance runners losing, on average 0.82 % more weight than sprinter runners. This data supports that of the previous study by Watson et al. (2005) stating that distance runners tend to lose more weight due to sweat, than do sprinter runners. Even though distance runners and sprinter runners were exercising in the same, controlled environment these findings could be attributed to a variety of different things.

First, it is possible that the distance runners were exercising at a higher intensity than their sprinter counterparts or that the particular practices in which data was collected happened to be more demanding for distance runners than for sprinter runners. Second, it is possible that the distance runners were exercising for a longer period of time during the specific data collections. Although coaches try to make practices consistent and fair, it is possible that distance runners took fewer breaks during their respective practices, resulting in a longer workout period and causing more sweating than the sprinter runners. This could be supported by the findings in this study that distance runners did not consume water during their practice sessions, where as sprinter runners did in fact take breaks to consume water during practice. Finally, the distance runners who participate in the University of Wisconsin Stout track program are also a part of the cross-country team as well. Therefore, it is possible that the distance runners were more acclimatized to exercise at this point in the track season than were the sprinter athletes. Distance athletes usually train year round and could have been at a higher level of fitness at this point in the season, causing them to sweat more in their state of higher fitness.

Overall, the findings of this study support the some of the hypotheses made in chapter I and disprove others. For the sprinter athletes, all of the hypotheses were supported in regards to the indoor environment, however since no data was collected for the outdoor season, it is inconclusive whether or not the hypotheses for the outdoor season were supported.

The first hypothesis was that fluid losses in both environments would be significant, defined as a weight loss great than or equal to 1.5% of pre-training body mass. As explained earlier in the chapter, for distance runners in the indoor season, the average percentage of weight loss was 1.90%, which was found to be statistically significant, therefore supporting this hypothesis. For sprinter runners, however, no statistically significant losses were found in either environment, disproving the first hypothesis of this study for sprinter runners. The average percentage of weight loss was only 1.08% for the indoor season and 0.86% for the outdoor season, both of which are lower than the statistic of 1.5% used for this present study.

The second hypothesis was that the fluid losses in a dry, controlled indoor environment would be greater than or equal to those of an uncontrolled, outdoor environment for both groups of runners. This hypothesis was indeed supported in the sprinter athletes as they experienced, on average, a statistically significant greater percentage of weight loss during the indoor season than during the outdoor season. This hypothesis could neither be supported nor disproved for the distance runners since no data was obtained for them during the outdoor season. Although statistically significant differences were experienced during the indoor season, further research needs to be done to determine if greater losses are experienced indoors as compared to outdoors.

Finally, the last hypothesis stated that there would be no apparent correlation seen between the sweat lost and the fluid consumed in each individual season for both groups of runners. This hypothesis was disproved for the sprinter athletes in both environments, as a statistically significant, positive correlation was found between the amount of water consumed and the amount of weight lost for both environments in these athletes. Those sprinter runners who consumed the most amount of water were also the ones to lose the most weight in both environments. The hypothesis could neither be supported nor disproved for the distance athletes as during the indoor season none of the athletes consumed and water and no data was obtained for the distance athletes during the outdoor season.

Recommendations

As explained in chapter II, the equation of weight lost during exercise (ounces) + fluid consumed during exercise (ounces) is equal to the amount of water players are suggested to then consume during exercise to insure proper replacement of sweat losses. According to the average losses experienced during the indoor season, sprinter athletes are not experiencing statistically significant fluid losses, but the losses they did experience were near those of concern (1.08% compared to 1.5%). It is important that each individual athlete is aware of his or her specific rate of weight loss through sweat and counterbalance it by taking in enough water at each practice session. Average losses experienced during the outdoor season were even less than those experienced during the indoor season (0.86%), but should still be considered on an individual basis in order to make sure fluids are being replaced. Specific recommendations of water intake for each athlete for both seasons can be obtained in Appendix J.

With all of this being said, it would be beneficial for each individual runner to determine his or her specific weight loss pattern in an effort to drink the amount of water recommended to replace what is being lost. The raw data and water intake recommendations included in this study could be an important tool for the runners; they document specific, individual losses and allow runners them to see the amount of sweat being lost in each respective season. This could be more beneficial than the overall conclusions of this study, as they are based on the average losses of the groups as a whole.

Distance runners should make an effort to consume water during practices, as no water was consumed during the indoor season and it is likely that little to none would have been consumed during the outdoor season as well. Coaches and staff should encourage breaks during practices to ensure water is being consumed and promote athletes to stop for a drink or carry a bottle with them when exercising outdoors when water is not readily available. As mentioned earlier in the chapter, distance runners experienced a statistically significant percentage of weight loss and it is critical that they try to offset these losses, as a hindrance in performance can be experienced at a dehydration level of as little as 2% (see chapter II). Distance runners, on average are very near this statistic at 1.90% (raw data can be obtained from appendix H) and therefore it would be in the best interest of the runners and coaches to encourage more water consumption during both practices and competitions. Recommendations for the distance runners' indoor season can be obtained on an individual basis in Appendix J.

Sprinter runners had a wide range of sweat ranges from 0.7-1.6% during the indoor season and 0.4-1.6% during the outdoor season, as can be seen in the raw data in appendix I. This reflects the importance of each athlete's role in paying attention to their specific weight loss needs and learning to adapt to their personal sweat loss rates accordingly. As mentioned in chapter II, the rate of sweat loss will vary from one individual to the next based on a variety of different factors. This study could help these athletes determine his or her sweat rate as high, medium, or low, which could assist them with the replacement of water during practices and other activities. It's also important for the athletes to realize the value of replacing their sweat losses with electrolytes such as sodium and potassium to counterbalance any losses experienced with sweat in addition to fluid losses.

Additional data needs to be gathered to determine if there is, in fact, a statistically significant difference between the amount of body weight lost during the indoor season and the outdoor season for both sprinter and distance runners. The methods used in this study could be used as a model for future research, as the collection process was noninvasive and simple. Research would ultimately be performed during a more normal seasonal year, where data can be obtained for both groups in an optimal, outdoor environment.

Finally, recommendations for the distance runners and coaches include making sure that their athletes consume enough water during indoor practices, as statistically significant losses were seen in the distance athletes. Also, although sprinter runners did not have statistically significant losses in either environment, it's recommended that they recognize the amount of water they are losing during the indoor environment, as these losses were statistically significantly higher than during the outdoor environment.

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Appendix A: RPE Scale

Instructions for Borg Rating of Perceived Exertion (RPE) Scale

While doing physical activity, we want you to rate your perception of exertion. This feeling should reflect how heavy and strenuous the exercise feels to you, combining all sensations and feelings of physical stress, effort, and fatigue. Do not concern yourself with any one factor such as leg pain or shortness of breath, but try to focus on your total feeling of exertion.

Look at the rating scale below while you are engaging in an activity; it ranges from 6 to 20, where 6 means "no exertion at all" and 20 means "maximal exertion." Choose the number from below that best describes your level of exertion. This will give you a good idea of the intensity level of your activity, and you can use this information to speed up or slow down your movements to reach your desired range.

Try to appraise your feeling of exertion as honestly as possible, without thinking about what the actual physical load is. Your own feeling of effort and exertion is important, not how it compares to other people's. Look at the scales and the expressions and then give a number.

6 No exertion at all
7 Extremely light (7.5)□8
9 Very light
10
11 Light
12
13 Somewhat hard
14
15 Hard (heavy)
16
17 Very hard
18
19 Extremely hard
20 Maximal exertion

9 corresponds to "very light" exercise. For a healthy person, it is like walking slowly at his or her own pace for some minutes

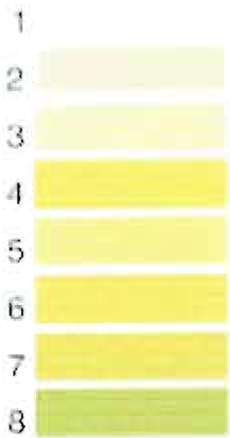
13 on the scale is "somewhat hard" exercise, but it still feels OK to continue.

17 "very hard" is very strenuous. A healthy person can still go on, but he or she really has to push him- or herself. It feels very heavy, and the person is very tired.

19 on the scale is an extremely strenuous exercise level. For most people this is the most strenuous exercise they have ever experienced.

Appendix B

Urine Color Measurement



Description / procedure: The sample is usually collected first thing in the morning. It may also be of interest to collect samples prior to or post exercise, though there may be a time delay for the effect of dehydration to show in the urine color.

Interpretation: Best results are seen when a white background is present, in good light, and the color is then compared to the chart above. The lower the number, the better the result. A urine color rating of 1, 2 or 3 is considered to be well-hydrated (Armstrong, 2000). Based on these results, changes in fluid intake can be made.

Precautions: Certain medicines and vitamins may cause the color of the urine to change. If any of these have been taken, this test is unreliable.
The colors your see on the screen, or when you print the image out, may appear different to the original chart. Therefore this chart should only be used as a guide. If more accurate comparison is required, please go to an original source.

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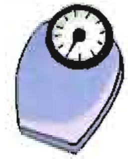
USATF Self-Testing Program for Optimal Hydration



from *Proper Hydration for Distance Running – Identifying Individual Fluid Needs*, by Douglas J. Casa, PhD, ATC, FACSM.

Any time a runner hits the road, track, or trail to perform in a race or training session, the need to properly hydrate becomes an issue. It has long been preached to runners (and all athletes) that you should consume "as much fluid as possible" to ward off the demons of dehydration. More recently, runners and medical staff have been told to limit hydration due to the potential dangers associated with overhydrating that can occur when running for an extended period of time. So what does the runner do to address the issues related to hydration?

In USATF's new hydration guidelines, long-distance runners are instructed to consume 1 liter of fluid for every liter lost during a race. Runners should determine their fluid needs well before any race longer than an hour, by using the following procedure during a 1-hour training run. If possible, do this session in climatic conditions similar to those at the race.

1. Make sure you are properly hydrated BEFORE the workout – your urine should be clear.
2. Do a warm-up run to the point where perspiration is generated, then stop. Urinate if necessary
3. Weigh yourself naked on an accurate scale
4. Run for one hour at an intensity similar to your targeted race.
5. Drink a measured amount of a beverage of your choice during the run if and when you are thirsty. It is important that you keep track of exactly how much fluid you take in during the run.
6. Do not urinate during the run.
7. Weigh yourself naked again on the same scale you used in Step 3.
8. You may now urinate and drink more fluids as needed. Calculate your fluid needs using the following formula:

A. Enter your body weight from Step 3 in Pounds		________
	–	
B. Enter your body weight from Step 7 in Pounds		________
C. Subtract B from A	=	________
	x	15.3
D. Convert your total in C to fluid ounces by multiplying by 15.3	=	________
E. Enter the amount of fluid you consumed during the run in ounces	+	________
F. Add E to D	=	________

The final figure is the number of ounces that you must consume per hour to remain well-hydrated.

Now you know how much you need to drink per hour in order to stay properly hydrated during a race or a long hard training run. Keep in mind that as you get in better shape over time, you may need to perform this test again to make sure that your fluid needs have not changed. By the same token, if you reduce or change your training significantly, you may also need to perform the test again.

If the expected climatic conditions for your race or long training runs change, you will also need to perform the test again in as close to the new climatic conditions as possible. Keep in mind that we now know that when conditions get hot, drinking sufficient water will not be enough to prevent heat-related illness. As the temperature rises, you simply have to slow down.

Of additional importance is determining the type of fluids to drink. In many situations, athletes can benefit from including carbohydrates and electrolytes (especially sodium) in their rehydration beverages. However, just as individual differences exist in sweat lost during exercise, individuals also can differ in the types of beverages that are most suitable. Once you have determined how much fluid you need to consume, you should begin incorporating this fluid consumption into your training runs. It is during these practice sessions that you can find out what type(s) of beverage will work best for you.

More information on hydration, including the full paper by Douglas Casa, can be found at www.usatf.org

Appendix D: Example of Consent Form

Consent to Participate In UW-Stout Approved Research

Title: Fluid losses of Division III track athletes experienced during indoor versus outdoor seasons

Investigator: Melanie Mertes
Phone Number: (218)348-3155
Email: mertesm@uwstout.edu
Office: N/A

Research Sponsor: Anne Hoel
Phone Number: (715) 232-1109
Email: hoela@uwstout.edu
Office: 245 Tech Wing

Description:
The objective of this study is to examine fluid losses experienced by athletes in a dry, indoor environment and a humid, outdoor environment to quantify and compare them. The significance of this study is to determine the effect a dry, indoor environment has on the fluid losses of athletes. As an avid exerciser and former athlete, the benefits of this research are intriguing and understood. This research would be beneficial because although plentiful research is available on the effect humid weather has on water losses in athletes, but little is available regarding dry, indoor environments. Many people in People residing in Northern regions have experienced dry skin and mouth, relative to dry weather. This study aims to determine how this climate affects athletes' water losses, and potentially performance. This study proposes to offer information on the hypothesized increased water needs of athletes during and indoor track season, in order to raise awareness of possible performance hindering properties. This information could then be useful to any Division III track team, as it will benefit all indoor runners.

Methods:
All participants will participate in two data collections, collection A, which will occur in a dry, indoor environment and collection B, which will occur in a humid, outdoor environment. Collection A will consist of a week worth of practices during January 2008. Collection B will consist of a week worth of practices during April 2008. For both data collections, participants will report to the scale, located by the athletic training room on the UW-Stout Campus, daily as they proceed to practice. Upon arriving to each session, each participant will be weighed, by the researcher, on a tarred scale wearing only shorts (and if desired a shirt) for males or only shorts and a sports bra (and/or t-shirt if desired) for females. This pre-practice weight will be recorded immediately and kept in close watch by the researcher at all times. Participants will then go about their scheduled practice sessions as scheduled by their respective coaches. During these practice sessions, athletes will be asked to drink out of a standardized water bottle, recording approximately how many they drink to the nearest half-bottle. Immediately following the practice sessions, participants will be instructed to towel off any excess sweat, remove any sweat soaked clothing, and report back to the weigh in area. Here they will report how many bottles they consumed, as well as undergo another weigh-in wearing the same amount of clothing as before. The researcher will then record fluid consumed and post exercise weights in the table next to pre practice weights. This data will then be placed into the file

of each participant and kept private and secured by the researcher until passed off to the third party.

Risks and Benefits:
There are minimal to no risks associated with this study. It is possible that some may not want their weight to be known, and if this is the case, the researcher will allow them to record their own weight onto the sheet, as all subjects will be coded with numbers not names. It is possible that injuries could occur during this study, as it is an actual sport with competitions, practices, and real life situations. It is important to note, however, that these injuries would not be directly linked to the study.
There are a few benefits to the subjects of this study. They will be able to track and understand their own personal fluid losses and possibly be able to develop a personal plan to optimize their performance by maintaining hydrated. They will also be able to see the difference between how exercising in dry weather affects their body versus how exercising in humid weather does. The information obtained in this study can be allocated to Division III track teams across the United States.

Time Commitment and Payment:
Subjects will be required to weigh in before and after each scheduled practice for a one-week period in January and a one-week period in April. This will only take seconds before and after each athlete. The water intake of athletes will be recorded during sessions by standardizing water bottles and asking athletes to record approximately how many they drank throughout the practice.
There will be no payment and/or incentive for participating in this study.

Confidentiality:
To maintain confidentiality, each subject will be assigned a number, under which all of their recorded data will be stored. The names and codes will be kept by a third party in order to keep the study blind and the number will only be known by this individual and the subject. All records will be kept confidential and safe in a designated area to which no other individuals have access. This folder will be kept with the researcher during research sessions and with the third party individual at all other times.

Right to Withdraw:
Participation of each subject in this study is entirely voluntary. It is your right to choose not to participate in this study without any adverse consequences. Should you choose to participate, you may discontinue your participation at any time if you and later wish to withdraw from the study, without incurring adverse consequences.

IRB Approval:
This study has been reviewed and approved by The University of Wisconsin-Stout's Institutional Review Board (IRB). The IRB has determined that this study meets the ethical obligations required by federal law and University policies. If you have questions or concerns regarding this study please contact the Investigator or Advisor. If you have any questions, concerns, or reports regarding your rights as a research subject, please contact the IRB Administrator.

Investigator:
Melanie Mertes
Services
(218) 348-3155 mertesm@uwstout.edu

IRB Administrator:
Sue Foxwell, Director, Research

152 Vocational Rehabilitation Bldg
UW-Stout
Menomonie, WI 54751
(715) 232-2477
foxwells@uwstout.edu

Advisor:
Anne Hoel hoela@uwstout.edu
245 Tech Wing
UW-Stout
Menomonie, WI 54751
(715) 232-1109

Please Tear/Cut here

Please read below, sign, and return to the researcher. Thank you for your time.

Statement of Consent:
By signing the following, you agree to participate in the project entitled Fluid losses of Division III track athletes experienced during indoor versus outdoor seasons.

Signature.. Date ______________

Appendix E: Example of Weight Chart (Used for Sprinter and Distance Runners)

Weight Chart and Water Intake of (indoor / outdoor) Season for ____________(Month)

Date	Pre-weight	Post-weight	# Cups Consumed
Day 1:			
Day 2:			
Day 3:			
Averages:			

Appendix F: Example of Water Tally Sheet for Sprinter and Distance Runners

Distance Runner's Water Count by Cups for ______________________ (Date)

ID Number	Number Cups Consumed (Tally)
201	
202	
203	
204	
205	
206	
207	
208	
209	
210	
211	
212	
213	
214	
215	
216	
217	
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220	
221	
222	
223	
224	
225	
226	
227	
228	
229	
230	
231	
232	

Appendix G: Sprinter Runner's Water Record Table

Distance Runner's Water Count by Cups for __________________________ (Date)

ID Number	Number Cups Consumed (Tally)
301	
302	
303	
304	
305	
306	
307	
308	
309	
310	
311	
312	
313	
314	
315	
316	
317	
318	
319	
320	
321	

Appendix H: Distance Runner's Raw Data Averages

Distance Runner's Average Weight Loss & Percentage Weight Loss Raw Data

Indoor	Season			
ID number	pre weight	post weight	weight lost	percent
208	144.9	142.6	2.3	1.6
202	119.3	117.6	1.7	1.4
209	129.4	127.1	2.3	1.8
214	157	155.5	1.5	o.9
210	126.8	124.9	1.9	1.5
205	121	118	3	2.5
222	137	134.3	2.7	2
207	148.9	145.8	3.1	2.1
221	156.1	151.5	4.6	2.9
223	159.3	155.8	3.5	2.2
226	128.4	126.8	1.6	1.2
211	164.7	161.7	3	1.8
206	146.9	142.8	4.1	2.8
227	128.7	126.6	2.1	1.6
203	148.4	146.3	2.1	1.4
201	152.2	148.1	4.1	2.7

Appendix I: Sprinter Runner's Raw Data Averages

Sprinter Runner's Average Weight Loss & Percentage Weight Loss Raw Data

Indoor	Season	Averages			
ID Number	Pre weight	Post weight	Wt Lost	Percentage	H2O Drank
307	**135.6**	**133.3**	**2.3**	**1.6**	**25.5 oz**
310	**146.1**	**144.3**	**1.8**	**1.2**	**10.5 0z**
320	**174.9**	**173.4**	**1.3**	**0.7**	**18.5 oz**
317	163.6	162	1.6	1	12.5 oz
316	**161.2**	**159.4**	**1.8**	**1.1**	**37.3 oz**
314	**122.1**	**120.9**	**1.2**	**1**	**9.5 oz**
301	**165**	**163.3**	**1.7**	**1**	**10.5 oz**
302	**115.9**	**114.8**	**1.1**	**0.9**	**8 oz**
306	173.9	171.9	2	1.2	21.5oz
311	**160.4**	**159.2**	**1.2**	**0.7**	**0 oz**
319	161.4	159.6	1.8	1.1	26.5 oz
315	**158.9**	**156.4**	**2.6**	**1.6**	**26.5 oz**
304	142.7	141.6	1.1	0.8	24 oz
303	163.7	161.5	2.2	1.3	16 oz
309	**146.6**	**145.6**	**1**	**0.7**	**12 oz**
308	204.3	202.4	1.9	0.9	26.5 oz
312	**152.9**	**150.5**	**2.4**	**1.6**	**18.5 oz**
313	**134.6**	**133.5**	**1.1**	**0.8**	**0 oz**
321	122.1	120.5	1.6	1.3	32 oz
Outdoor	Season	Averages			
ID Number	Pre Weight	Post Weight	Wt. Lost	Percentage	
307	**137.3**	**135.5**	**1.8**	**1.3**	**22 oz**
310	**145**	**144.4**	**0.6**	**0.4**	**10.5 oz**
320	**176.6**	**175.4**	**1.2**	**0.7**	**8 oz**
317	none	none	none	none	none
316	**161.7**	**160.7**	**1**	**0.6**	**0 oz**
314	**129.4**	**128**	**1.3**	**1**	**6.5 oz**
301	**164.6**	**163.1**	**1.5**	**0.9**	**5.0 oz**
302	**114.1**	**113.3**	**0.8**	**0.7**	**2.5 oz**
306	none	none	none	none	none
311	**162**	**161.2**	**0.8**	**0.5**	**0 oz**
319	none	none	none	none	none
315	**159.8**	**157.7**	**2.1**	**1.3**	**10.5 oz**
304	none	none	none	none	none
303	none	none	none	none	none

309	**146.7**	**145.4**	**1.3**	**0.9**	**10.5 oz**
308	none	none	none	none	none
312	**154**	**151.5**	**2.5**	**1.6**	**10.5 oz**
313	**123.2**	**122.7**	**0.5**	**0.4**	**0 oz**
321	none	none	none	none	none