Hydration Knowledge and Habitual Practices of Female Collegiate Athletes in Training and Competition

By

Holly Elizabeth Clarke, ACSM EP-C, NSCA CSCS

A thesis submitted to the Graduate Faculty of
Auburn University at Montgomery
In partial fulfillment of the requirements for the
Degree of Master of Education in Exercise Science
Montgomery, Alabama
May 6th, 2017

Hydration Knowledge and Habitual Practices of Female Collegiate Athletes in Training and Competition

Except where references have been appropriately made to the work of others, the work described in this thesis is my own or was done in collaboration with my advisory committee. This thesis does not include propriety or classified information.

Holly E. Clarke

Certificate of Committee Approval:

Matthew Schubert
Thesis Committee Chair
Auburn University Montgomery
Kinesiology

Hank Williford
Thesis Committee Member
Auburn University Montgomery
Kinesiology

Kyle Taylor
Thesis Committee Member
Auburn University at Montgomery
Medical & Clinical Lab Sciences

Sheila Austin
Dean
Auburn University at Montgomery
School of Education

Abstract

The purpose of this study was to investigate hydration habits, the prevalence of dehydration, and hydration knowledge of female collegiate soccer players over a 2 week period. Nineteen college-level female soccer players participated (mean ± SD; age: 20.4 ± 0.8 years; body height: 163.6 ± 6.9 cm; body mass: 65.3 ± 12.0 kg). Hydration status was assessed upon waking (AM) and pre-practice/game (PM) via U_{sg}. Athletes completed questionnaires addressing hydration knowledge (HHQ) and habitual fluid ingestion (BEVQ). 100% of players awoke with signs of dehydration (U_{sg} >1.010) on 5 out of 9 days. The highest incidence of significant or serious dehydration in the AM was 87% of total players; whereas, the highest in the PM was 67%. A significant effect of time ($p < 0.05$) was found, but no effect of day or time*day interaction ($p > 0.05$) were observed. Athletes had higher U_{sg} values in the morning compared to the afternoon on the same day. This was statistically significant on days 2, 5, and 7 ($p < 0.05$) with trends on days 3, 4, and 9 ($p < 0.09$). Pearson correlations revealed relationships between BEVQ total fluid ounces and mean U_{sg} (r = -0.60, $p < 0.05$) and BEVQ water consumption and mean U_{sg} (r = -0.53, $p < 0.08$). In conclusion, the high prevalence of dehydration is a concern for female soccer players, and could impede performance. Efforts should be made to develop and integrate hydration intervention and monitoring into daily training and competition.

Keywords: Urine Specific Gravity, soccer, hydration knowledge, female

ACKNOLWEDGEMENTS

I would like to take this opportunity to sincerely thank the faculty and staff of the AUM Department of Kinesiology for all the effort and support you have shown me throughout my career at AUM. Each and every one of you have helped fuel my passion for the field of Kinesiology, and have assisted in my development as a mature and prepared individual. To Dr. Matthew Schubert specifically, I would not have had the confidence to produce this work without your constant support, encouragement, guidance and phenomenal mentorship. I would also like to thank Dr. Hank Williford, not only for his contribution to the Department of Kinesiology for decades, but also for the teaching and direction you have given me as a student. I have upmost respect for the work you have done for this school and your students. In addition, I would like to thank Dr. Kyle Taylor, Dr. Michelle Olson, and Dr. Mike Esco for the inspiration you have given me and the positive influence you have had on my future aspirations. I have been lucky enough to have had a flawless laboratory to work in, alongside fellow graduate students that have supported me and become forever friends. Specifically, thank you to Rebekah Seay and Katie Spain who have been beyond amazing. To the coaches and athletes who participated and gave their time to allow me to collect data, thank you; this work would not have been possible without your contributions. Finally, thank you to my family and friends who have been the foundation of my happiness and success as a student embarking on a degree that I love, so far away from home.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

LIST OF ABBREVIATIONS

WHO	World Health Organization
NHANES	National Health and Nutrition Examination Survey
U_{sg}	Urine Specific Gravity
NCAA	National Collegiate Athletics Association
U_{osm}	Urine Osmolality
P_{osm}	Plasma Osmolality
ACSM	American College of Sports Medicine
NATA	National Athletic Trainers Association
BM	Body Mass
FIFA	Fédération Internationale de Football Association
NAIA	National Association of Intercollegiate Athletics
HR_{max}	Maximum Heart Rate
VO_{2max}	Maximal Oxygen Uptake
WBGT	Wet Bulb Globe Temperature
EHI	Exertional Heat Illnesses
HHQ	Hydration Habits and Knowledge Questionnaire
BEVQ	Beverage Questionnaire
AM	Morning sample
PM	Pre-practice/ Pre-game sample
AI	Adequate Intake

Chapter 1

Hydration Knowledge and Habitual Practices of Female Collegiate Athletes in Training and Competition

Introduction

According to the Fédération Internationale de Football Association (FIFA), the global governing body of football or "soccer", it has been estimated that over 265 million males and females of all ages participate in soccer around the world ("Big Count" FIFA Survey, 2006). Soccer is a high intensity, intermittent sport (Ekblom, 1986); calling upon both aerobic and anaerobic systems for the provision of energy metabolism (Reilly, 1997; Stølen et al., 2006). With an overall game intensity reaching ~70-80% of one's VO_{2max} (Bangsbo, 1994); maximal heart rates ranging from 80-90% HR_{max} (Alexandre et al., 2012; Billows et al., 2005); and players covering up to 7 miles in an average game (Bradley et al., 2009), the physiological impact put upon a player's body is vast. Often forgotten, soccer also requires agility and muscular strength and endurance for more explosive movements such as sprinting, jumping, kicking, and rapid changes of direction (Cometti et al., 2001; Davis et al., 1992; Wisløff et al., 1998).

The intensity of soccer combined with the cardiovascular, agility, and muscular strength components are collectively sufficient to elevate core body temperature (Edwards & Clark, 2006). With an increase in metabolic heat production, core temperatures have been found to reach 39-40^{o}C during match play (Maughan & Leiper 1994). This inevitable increase in core temperature leads to an increase in sweat rate. Maughan et al. (2004) and Shirreffs et al. (2005) found that the average sweat rate of a soccer player can range from 1-3L per game. Considering the water content of sweat, unless players replace fluid which is lost, they could risk experiencing net loss of body water (Edwards & Noakes, 2009). The high risk and high prevalence of dehydration in soccer players, causes firm grounds for concern.

Dehydration, or *hypohydration,* has been widely characterized by a loss of body mass of ≥2% (Murray, 2007). Dehydration can have numerous adverse effects on the functioning of the human body, for example cardiovascular impairment (Maughan, 2003); decrements in cognitive functioning (Cian et al., 2000). In addition to these, athletes performing in a state of dehydration can experience further sport specific impairments. A seminal study by Montain & Coyle (1992) found that the increase in heart rate and core temperature was proportional to the extent of dehydration. Similarly, Coyle (1998) found that with progressive stages of dehydration came increases in heart rate, temperature, and ratings of perceived exertion. Rothenberg & Panagos (2008) also discussed the deleterious effects of poor hydration status on musculoskeletal performance. Smith et al. (2012) found that a state of dehydration significantly influenced both the motor and cognitive performance of elite golfers. Accuracy, driving distance, and distance judgement were all impaired. Exercising in a state of dehydration has also been shown to affect fuel utilization (Barr, 1999). Hargreaves et al. (1996) found that when no fluid was provided to subjects during a 120-minute cycle exercise, heart rate and core temperature increased rapidly; subsequently, a reliance on carbohydrate oxidation was apparent. In more extreme cases dehydration can also exacerbate the risk of varying exertional heat illnesses (EHI) such as muscular cramps, heat syncope, heat exhaustion and heat stroke (Casa et al., 2015; Casa et al., 2000; Kenefick & Sawka, 2007).

Given the concerns regarding dehydration and athletes, and with insufficient hydration having potential impacts on sport performance, one would assume players and coaches would monitor hydration status carefully. Monitoring hydration can be done in both field and laboratory settings through varying techniques. Some more precise monitoring techniques often require expensive and stationary devices such as Urine Osmolality (U_{osm}), Plasma Osmolality (P_{osm}), and Isotope Dilution; most of these methods are not practical for field use. However, other methods are more portable and useful in the field, such as Urine Specific Gravity (U_{sg}), observing Urine Color (UC) and changes in body mass. Guidelines and thresholds determining dehydration levels for each of these techniques have been published by the National Athletic Trainers Association (Casa et al., 2000 NATA position statement). Despite this array of monitoring techniques, however, multiple studies have shown that the prevalence of dehydration in soccer is still alarmingly high across all levels.

Phillips et al. (2014) monitored hydration status over 3 consecutive training sessions in elite male soccer players (n= 14; 16.9 ± 0.8 years). Taking morning, pre and post training U_{sg}, dehydration was indicated by a value of ≥1.020. It was found that 77% of players attended practice already in a dehydrated state on day 1 and 3, and 62% on day 2. Data from a study conducted by Castro-Sepulveda et al. (2016) found similar results in 17 international-level female soccer players (21.5 ± 3 years). The athletes were evaluated for hydration status prior to 3 sport events: training (PT), friendly match (PF), and an official game (PO). U_{sg} was used to detect significant (1.021-1.030) or severe dehydration (>1.030). It was found that dehydration was prevalent across all events. Average U_{sg}

($\bar{x} \pm SD$) across all 3 events was 1.027 ± 0.007 (PT = 1.029 ± 0.009; PF = 1.023 ± 0.010; PO = 1.030 ± 0.006). Additionally, Gibson et al. (2012) evaluated the pre-training hydration status of 34 junior elite female soccer players (15.7 ± 0.7 years) over the course of 2 typical 90-minute sessions, separated by one week (T1 and T2). There were no significant differences in U_{sg} between T1 and T2, however individual data showed that 45.4% (n=30) of players presented to training in a dehydrated state (>1.020). Specifically, 40.9% (n=27) of these were significantly dehydrated (U_{sg} 1.020-1.029); and 4.5% (n=3) were seriously dehydrated (U_{sg} >1.030).

Dehydration in soccer has been associated with earlier elevations in core temperature and heart rate (Ali et al., 2011), as well as impairments in soccer-specific skills (Edwards et al., 2007; McGregor et al., 1999). Despite evidence supporting the negative impact of dehydration on soccer performance, and further evidence showing the vast prevalence of acute dehydration in soccer teams of all levels, considerably less research has looked at the habitual hydration of athletes over longer periods of time. Having a more thorough understanding of habitual levels of hydration could allow the development of more effective intervention strategies, athlete education, and individual monitoring which could be beneficial in reducing the prevalence of dehydration and heat-related illnesses (Magee et al., 2016; Judge et al., 2016; Maughan & Shirreffs, 2010; Murray, 1996). Therefore, the purpose of this study was to investigate the hydration habits of female collegiate soccer players, over a 2-week period; inclusive of training sessions, official games and rest days.

Methods

Subjects

Nineteen college-level female soccer players were evaluated (age: 20.4 ± 0.8 years; body height: 163.6 ± 6.9 cm; body mass: 65.3 ± 12 kg) during this study. Prior to any contact with the team, the current head coach and athletic trainer were informed of the purpose of the study and approval was obtained prior to contacting players. A brief explanation was given regarding the potential benefits and risks of the study. All players deciding to participate gave full informed consent and completed a health history questionnaire. The experimental protocol was reviewed and approved by the Auburn University at Montgomery Institutional Review Board.

Hydration Habits, Knowledge and Beverage Questionnaires

Following the completion of an informed consent and a health history questionnaire, participants completed a *Hydration Habits and Knowledge Questionnaire* (HHQ) and *Beverage Questionnaire* (BEVQ). The purpose of the HHQ was to assess the general knowledge of hydration concepts, the importance of these concepts and the beliefs of hydration's relevance to sporting ability and performance. The HHQ was based on that previously used by Decher et al. (2008). Questions were formatted using a Likert-type scale rating from 0 (negative response: not important; never; not at all; strongly disagree) to 10 (positive response: very important; always; a lot; strongly agree); others used a multiple-choice format, with some questions requiring a written response or further explanation of the answer selected. The BEVQ assessed participant's own hydration habits, frequency, amount and type of fluid consumed. Participants were asked to indicate fluid recall over the last month of 15 varying drinks. Ratings were given for "How Often" they were consumed (<1 time per week; 1 time per week; 2-3 times per week; 4-6 times per week; 1 time per day; 2+ per day; 3+ per day) and "How Much Each Time" (<6 fl. oz; 8 fl. oz; 12 fl. oz; 16 fl. oz; > 20 fl. oz). BEVQ responses were scored using an excel sheet per the instructions of Hedrick et al. (2012, 2013) for total fluid and water ingestion (in ounces).

Experimental Design

Over a period of 2 weeks during a regular National Association of Intercollegiate Athletics women's soccer season, an observational study was conducted. Players who had completed an informed consent and who had no underlying health conditions, as indicated by the health history questionnaire, were assessed for hydration status. Every day, 2 urine samples were collected by each individual. The AM sample, representing waking hydration status, was taken using the first void of urine upon waking. This was collected by the participant in a sterilized, pre-sealed container distributed the day prior. The second PM sample was collected within 1 hour before initiation of each day's practice or game. Samples were gathered and stored for assessment. Participants were also given 2 new sample cups to use for the following day's sample collection. Urine was used to evaluate the hydration status of each player via the use of Urine Specific Gravity, in accordance with Casa et al. (2000). Samples were collected Monday through Friday; weekend samples were not required for this study. In total, over the period of 2 weeks, 10 days' worth of urine samples were collected.

In addition to urinary collection, environmental variables were also monitored each day. Time of practice/game, temperature (^{o}C), humidity (%) and Wet Bulb Globe Temperature (WBGT) were recorded. Over the course of the study, average PM temperature was 27.9 ^{o}C, average humidity was 60%, and WGBT was 23.91 ^{o}C.

Training and Dietary Standardization

Samples were collected at the same time each day (±1 hour). Participants were asked to continue with normal daily habits and to sustain normal dietary and fluid intakes. Participants were also asked to continue with training as they normally would. No recommendations or results were given to participants regarding fluid intake and hydration status to ensure participants were not influenced by outcomes and that data collection was conducted under normal, “real-life” conditions. Players currently taking prescription medicine or supplementation were asked to report this on their health history questionnaire.

Experimental Protocol

Urine samples were collected by participants every AM (upon waking) and PM (1 hour pre-practice/game). Participants were asked to collect a mid-stream urine sample in a sterile, evident seal, 4 oz. specimen cup to ensure a clean sample for later assessment. Samples were brought, sealed, to each PM event in which they were collected and stored in a portable, insulated cooler for transportation to an off-site laboratory. Once participants had turned in both samples, they were instructed to take 2 new specimen cups for next day sample collection. Samples were transported and stored over-night in room temperature conditions for next day urinary assessment. Both Adams et al. (2017) and Hunt et al. (2011) found that urinary hydration markers were stable 1-2 days after collection if stored in room (22^{o}C) conditions, with little or no change in urine specific gravity (U_{sg}). Samples were assessed for hydration status the following morning.

Urine was analyzed using a portable, handheld clinical refractometer (PEN-Urine S.G.; ATAGO Co, Tokyo, Japan) which was calibrated as per manufacturer's instructions using distilled water. Each urine sample was measured by the same researcher, with the refractometer being returned to a "Zero Setting" and wiped (Kimwipes; KIMTECH) before each subsequent analysis. Each sample measurement was repeated twice. If measurements varied by >0.0010, a third measurement was taken and an average was determined from the two most consistent measurements. Samples were identified and related to participants via a secure coding system. All urine samples were disposed of appropriately following assessment, and empty sample containers were discarded in a biohazards bag.

Hydration status was indicated using U_{sg} values in reference to cut-off values as proposed by Casa et al. (2000). Classifications were as follows: <1.010 (well hydrated); 1.010-1.020 (minimal dehydration); 1.021-1.030 (significant dehydration); and >1.030 (serious dehydration).

Statistical Analysis

Data were analyzed using SPSS (v. 23, IBM SPSS Statistics, Chicago, IL, USA) and SAS University Edition (SAS Institute, Cary, NC, USA). Over the intervention, complete U_{sg} data from all sample points were only available for 8 participants. Missing data ranged from 6.3-25% for a given day. Missing value analysis using Little's Missing Completely at Random test was conducted and revealed that data were indeed missing in a random, non-biased way ($p = 0.17$). Due to the small size of our sample, multiple imputation was not considered "best practice", and a repeated-measures ANOVA would have limited statistical power due to exclusion of missing data. Instead, we utilized a mixed model with maximum likelihood estimation procedures in SAS (PROC MIXED). This method of analysis is more robust than the typical ANOVA, as this procedure permits the use of incomplete data, whereas general ANOVA procedures will discard any missing data. Mixed models utilize both fixed and random effects; fixed effects are usually effects of primary interest that would be used if the experiment was repeated, while random effects are considered to be a random selection or influence on the variance (West, Welch, & Galecki, 2015). Fixed effects included the time of day (AM vs. PM) and day of study (1-9) along with their interaction. Participant ID was included as a random effect along with its interaction with time and day (to allow for repeated measurements on participants between AM/PM and day of study). The Bonferroni test for multiple comparisons was conducted if significant effects were detected. Habitual hydration from the BEVQ was correlated with overall mean U_{sg} to examine the relationships between total fluid and water intake and hydration status using Pearson correlations. Data are presented as means ± standard deviations. Figures were prepared in using GraphPad Prism (v. 7, GraphPad Corp., La Jolla, CA, USA).

For the BEVQ and Hydration knowledge and habits questionnaires, there was a low respondent rate ($n = 6$). Therefore, we elected to analyze the data for descriptive statistics (mean, standard deviation, and range) for the scored questions and BEVQ and reported number of respondents for the open-ended questions. Some questions allowed participants to select more than one answer; therefore, responses do not always add up to 6.

Results

Nineteen participants supplied informed consent and started the study, but 3 were lost due to injury (n =1) or lack of interest (n = 2); thus, the final sample was 16 participants.

The incidence and extent of dehydration as determined by U_{sg} over 9 days in female college soccer players are shown in Figure 1 below. The highest incidence of significant/serious dehydration ($U_{sg} \geq 1.021$) in the morning (AM) was 87% on day 7, while 67% of players were dehydrated in the afternoon (PM) on day 6. Additionally, 100% of players awoke with signs of dehydration (U_{sg} >1.010) on 5 out of the 9 days. Conversely, the highest incidence of euhydration was 45% of players in the afternoon of day 9.

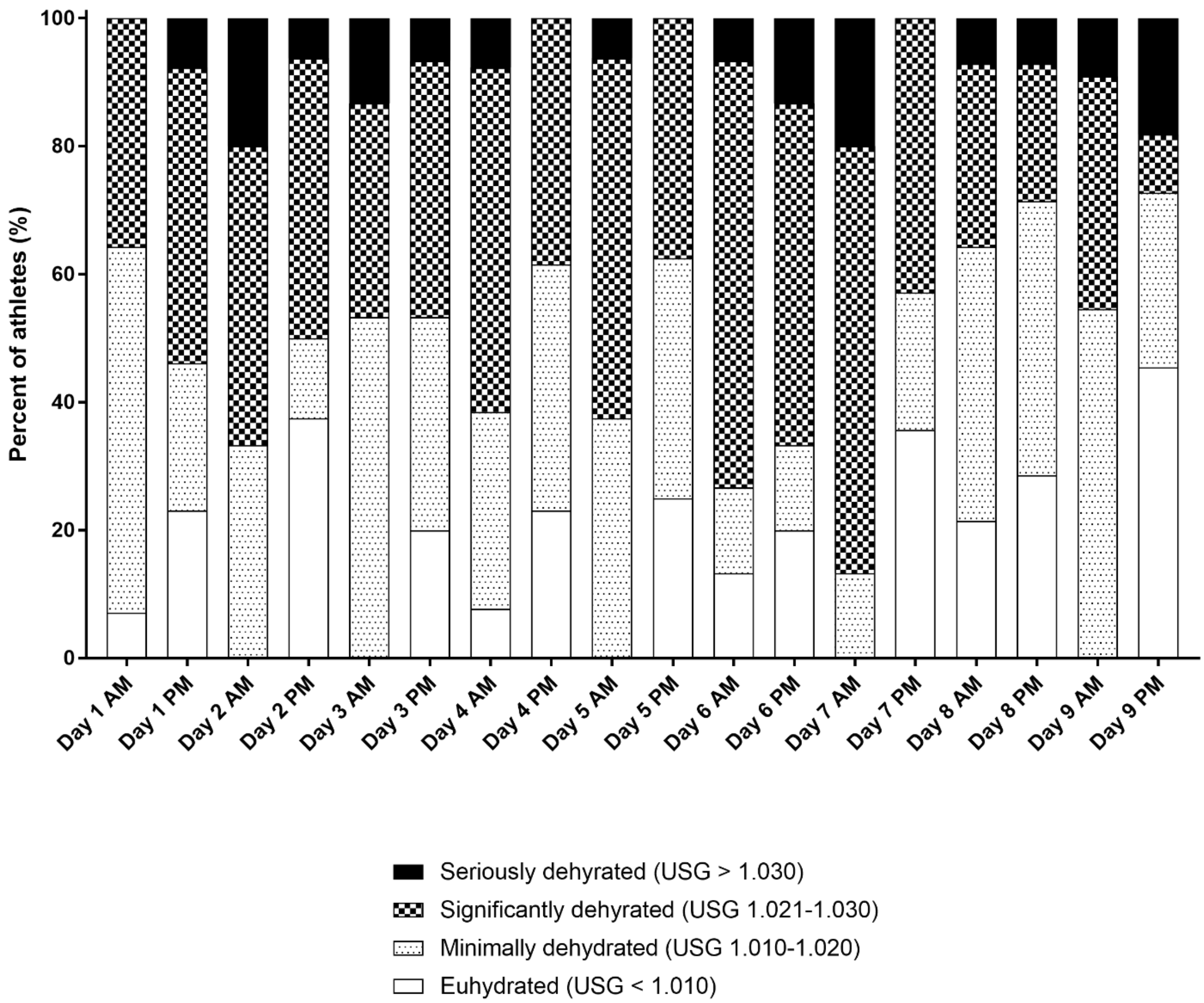

Figure 1: Percentage distribution of hydration status; as indicated by urine specific gravity (U_{sg})

Results of the mixed model indicated a significant effect of time of day ($p < 0.01$), but no effect of day ($p = 0.42$) or time*day interaction ($p = 0.47$). The model results indicated that the participants generally had higher U_{sg} scores in the morning compared to the afternoon samples on the same day (suggesting greater dehydration on waking). This was statistically significant on days 2, 5, and 7 ($p < 0.05$) with trends on days 3, 4, and 9 ($p < 0.09$). The time course of morning and afternoon samples are shown in Figure 2.

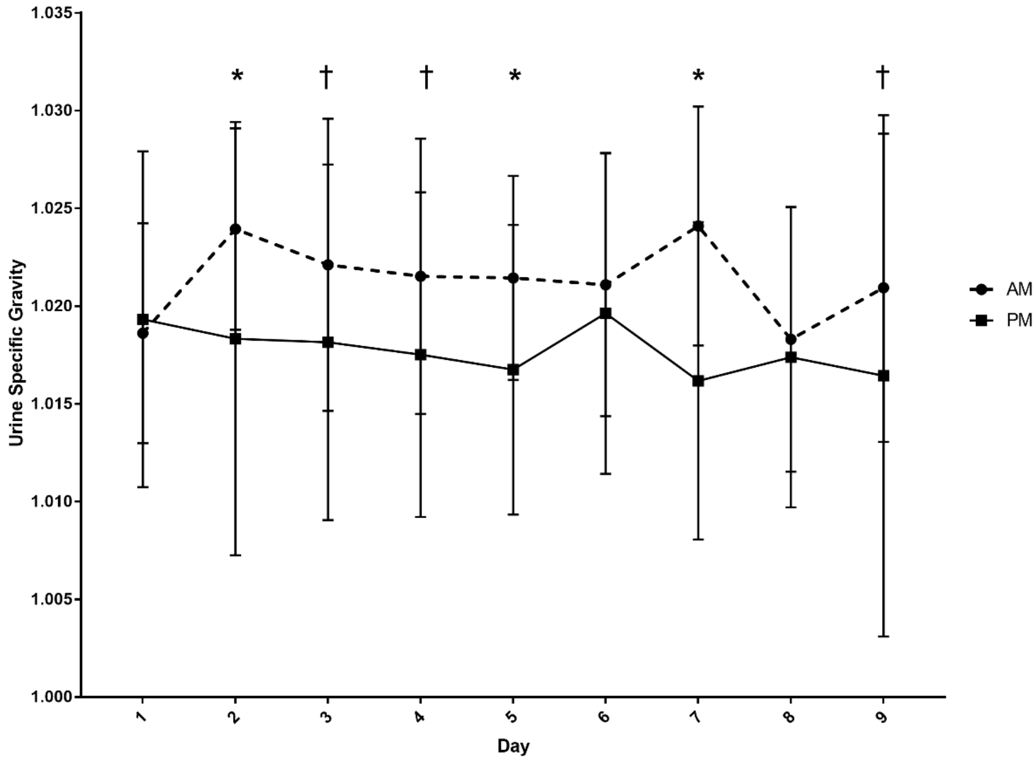

Figure 2: Mean AM and PM U_{sg} values. Error bars represent SD. *p<0.05, †p<0.09.

In regards to game days (days 3 and 5), participants' morning samples were not different from any other morning samples ($p > 0.05$); however, the morning sample on day 5 trended towards being greater than the pre-game sample ($p = 0.08$). Their pre-game samples were also not significantly different from any of the other afternoon pre-practice samples (all $p > 0.05$).

Pearson correlations revealed a negative relationship between BEVQ total fluid ounces and mean U_{sg} (r = -0.60, $p = 0.038$). BEVQ water consumption was negatively related to mean U_{sg} (r = -0.53, $p = 0.076$). After analyzing the BEVQ responses, the average total water consumed per day (ml/day ± SD) per individual was 867 ml/day ±

286 ml/day. Total overall fluid consumption per day (ml/day ± SD) per individual was 1346 ml/day ± 441 ml/day.

For descriptive purposes only, results from the hydration knowledge questionnaire (HHQ) are displayed in Table 3. Due to a small number of participants who responded, (n = 6), conclusions cannot be drawn from the existing data.

Table 3: Hydration knowledge and habits questionnaire results

Scoring	Question	Mean	Range
0 (strongly disagree) 10 (strongly agree)	How important do you feel that drinking fluids is while you play sports or exercise?	10	n/a
	Do you drink enough fluids while you play sports or exercise?	6	4 – 7
	Do you wish you could drink more fluids during practice and games?	5.8	5 – 8
	To be hydrated means to have a proper amount of fluids in your body	7.2	4 – 10
	I do not need to drink fluids to perform at my best in my sport	9.2	7 – 10

Number of players responding	What color is your urine if you are hydrated?	Bright Yellow = 4 Pale Yellow = 2 Dark Yellow = 0 Brown Yellow = 0
	In a normal game or practice, how frequently do you drink? (select all that apply)	Whenever I want = 1 Only during breaks = 2 When not playing = 2 When coach tells us = 1 I don't drink during practice/games = 0
	When I am thirsty it means: (select all that apply)	I am almost dehydrated = 2 I am already dehydrated = 3 My core body temperature is high = 1 It is not related to my hydration status or body temperature = 1
	It is important to drink:	Before and after exercise = 0 Before, during, and after exercise = 6 During and after exercise = 0 Before and during exercise = 0

Discussion

The purpose of the study was to investigate hydration habits and the incidence of dehydration in female collegiate soccer players over a 2-week period. Hydration status was assessed upon waking and prior to training sessions, official games, and rest days. The primary finding of the study was that ≥58% of female soccer players woke up and presented to every practice or game already in a state of dehydration (U_{sg} >1.010). Furthermore, the entire team (100%) was in a state of dehydration upon waking on 5 out of the 9 days (Figure 1); 2 of which were game days.

This high incidence of dehydration in female soccer players prior to training, indicated by percent of players with U_{sg} values of >1.010, is in accordance with incidence rates measured in international-level female soccer players by Castro-Sepulveda et al. (2016). Castro-Sepulveda found after observing 17 elite female soccer players, that on average only 2% of players attended training, friendly, or official matches in a euhydrated state; indicating that 98% of players presented to events already in a state of dehydration. In addition to similarities in findings, both the present study and Castro-Sepulveda's study were conducted in a field setting, with comparable temperatures (27.9^{o} C vs 29^{o} C). Hydration assessment was also analogous in that both studies using U_{sg} to detect hydration, with cut-off values as presented by Casa et al. (2000).

Gibson et al. (2012) also evaluated the hydration status of 34 junior elite female soccer players via U_{sg} and found that on average over 2 training sessions, 45.4% of players presented in a dehydrated state. The difference in results could be attributed to how during Gibson's data collection average temperatures were cooler than in the current study (9.8^{o} C vs 27.9^{o} C). A further study showing possible differences due to environmental conditions was conducted by Kilding et al. (2009). Kilding observed 13 international level female soccer players over 2 training sessions and found that the average U_{sg} for each were 1.014 ± 0.005 and 1.011 ± 0.005 respectively. These U_{sg} values, although still representing a level of dehydration, were lower than the average PM U_{sg} value for the current study, 1.0176 ± 0.0066. The temperatures of each training session in Kilding's study were 14^{o}C and 6^{o}C respectively, which is cooler than the current study's average temperature of 27.9 ^{o}C. This, again, could support the theory that ambient temperature can affect level, prevalence, and extent of dehydration in female soccer players.

Research has shown that being in a state of dehydration can impact physiological and skill related components of soccer performance. Edwards et al. (2007) looked at the sport-specific fitness (Yo-Yo Intermittent Recovery Test) of 11 male soccer players immediately post-match, over 3 separate experimental conditions: fluid intake (FL); mouth rinse only (MR); and no fluid intake (NF). It was found that the immediate post-match performance of a sport-specific fitness test (Yo-Yo) was significantly impaired in both the MR and NF experimental conditions. Total distance covered decreased by 13-15% in comparison to the FL condition. Comparably, McGregor et al. (1999) evaluated the effect of fluid ingestion, or no fluid ingestion, on performance of soccer skills. Following a 90 minute Loughborough Intermittent Shuttle Test (LIST), players completed a soccer skill and mental concentration test. It was found that without fluid ingestion, soccer skill performance deteriorated by 5%. Conversely, ingestion of fluid helped to inhibit premature increases in heart rate, ratings of perceived exertion and internal core temperature. Ali et al. (2011) also looked at the effect of fluid ingestion (FL) or no fluid (NF) on passing ability in 10 female soccer players. Participants performed the Loughborough Soccer Passing Test (LSPT) before and every 15 minutes during the LIST, as used by McGregor et al. Core temperature, heart rate, perceived exertion, blood lactate, sprint performance and skill ability were all monitored. It was found that the allowance of fluid (FL) led to favorable physiological (reduced core temperature and cardiovascular strain) and perceptual responses; however, there was no significant difference between trials in terms of skill and sprint ability. Furthermore, Armstrong et al. (2012) found that mild dehydration of ≥1.36% loss in body mass resulted in a degraded mood, increased perception of task difficulty, lower concentration and headache symptoms in young females. This could negatively impact stamina and sensation of fatigue, which could further inhibit performance variables.

It has been proposed that the physiological demands of soccer vary greatly between males and females. Skill level, technical ability (passing, footwork and dribbling), strength and endurance differ due to the overall speed of play (Kirkendall, 2007). This disparity in physiological stress could give reasoning behind why dehydration has led to differing magnitudes of affect between females and males in similar studies (Ali et al., 2011; McGregor et al., 1999). Regardless of this difference however, research has shown that fluid ingestion in both male and female soccer players helps to actively reduce core temperature and cardiovascular strain, while maintaining perceptual and soccer abilities. There is a need however for further research on the relationship between physiological requirements and impact of dehydration in female soccer players specifically.

A hypothesis made in the current study was that female soccer players with a good general knowledge, understanding, and attitude towards the importance of hydration would likely show positive hydration habits; however, this hypothesis was not supported. At the beginning of this study, athletes were given a Hydration Habits Questionnaire (HHQ) and Beverage Questionnaire (BEVQ). Regardless of the freedom to complete questionnaires at any point over the course of the study, very few participants completed and returned questionnaires (n=6). Other studies looking at the hydration knowledge of athletes have shown a disparity between knowledge and behavior. Judge et al. (2016) assessed hydration knowledge, attitudes, barriers and behaviors of 100 National College Athletics Association Division 1 (NCAA D1) student athletes. It was found that only 24% of athletes reported drinking sufficient amounts of fluid before, during, and post practice. Judge concluded that these athletes had inadequate knowledge regarding proper hydration and hydration misconceptions were common. Nichols et al. (2005) also assessed the hydration knowledge, attitudes, and behaviors of NCAA D1 athletes. A total of 139 athletes completed a survey concerning hydration and fluid replacement, in reference to position stands made by both the American College of Sports Medicine (ACSM) and National Athletic Trainers Association (NATA). Questions regarding hydration guidelines set by ACSM and NATA were frequently missed and answered incorrectly by athletes; additionally, most athletes lacked knowledge on the appropriate use of sports drinks. Nichols concluded that college athletes need to be further educated about proper hydration and fluid replacement practices, and that positive hydration behaviors should be reinforced by coaches and athletic trainers.

The BEVQ used in the current study looked to assess the amount and how often fluids were consumed per individual. Athletes were asked to indicate total amount consumed for varying fluids including water, fruit juice, milk, soft drinks, sweet tea, coffee/tea, alcohol, and energy drinks. Despite the small number of respondents, it was found that average total water consumed per day (ml/day ± SD) per individual was 867 ml/day ± 286 ml/day; whereas, average total fluid consumption per individual was 1346 ml/day ± 441 ml/day. Current daily adequate intake (AI) guidelines for water, as set by the Institute of Medicine (2005), are 3.7 L and 2.7 L for males and females respectively. In comparison to what was found in the current study, female athletes were only ingesting on average 1.3 L a day of total fluids, inclusive of water; this is only 48% of the daily AI. Due to the small respondent sample size assumptions cannot be generalized; however, other studies have found similar results supporting that many athletes frequently consume sub-optimal amounts of fluid (Coris et al., 2004; Silva et al., 2011; Luliano et al., 1998; Garth & Burke, 2013). Ideally, at a minimum, fluid intake of competing athletes should equal net sweat and urine losses (Casa et al., 2000). Efforts should be made to increase the awareness of inadequate fluid intake by athletes, with emphasis on the integration of hydration strategies and individualized hydration protocols to optimize fluid status and performance (Gisolfi & Duchman, 1992).

In the current study, athletes were observed over a longer period compared to previous studies. This represented habitual, day-to-day hydration behaviors as opposed to acute behaviors. Athletes were observed in the field and were asked to continue with normal daily habits, including physical activity, and to sustain normal dietary and fluid intakes. No recommendations or results were given to participants regarding fluid intake and hydration status to ensure participants were not influenced by hydration status. The use of U_{sg} as a tool for determining hydration status has been supported by literature (Oppliger et al., 2005). U_{sg} is more applicable in field conditions due to its portability, accessibility and ease of use (Armstrong, 2007); yet it has been determined as being as accurate as other laboratory methods such as urine osmolality (Armstrong et al., 1994; Cheuvront et al., 2010; Perrier et al., 2013). Additionally, the use of U_{sg} has been cited in many other studies looking at the field hydration status of soccer athletes prior, during and after events, permitting direct comparison of results (Ersoy et al., 2016; Gibson et al., 2012; Guttierres et al., 2011; Silva et al., 2011). Cut-off values were set in regards to those stated by Casa et al. (2000) in the NATA position stand regarding fluid replacement in athletes, and these cut-off values have been referenced in multiple other hydration studies (Castro-Sepulveda et al., 2016; Osterberg et al., 2009; Stover, 2006).

The nature of this field study did require some limitations. In some instances, athletes missed sample collection in either the AM or PM; forgot to return samples; or, dropped out due to injury or lack of interest. This influenced statistical power and analytical options. With PM samples being taken before practice or games, it is also possible that pre-exercise anticipatory mechanisms could have influenced renal activity and consequently effected urine concentration (Poortmans,1984). Environmental conditions were consistently warm throughout the study, which leaves room to argue whether a difference would have occured in a player's hydration status if environmental temperatures fluctuated between hot and cold weather between or within days. Although U_{sg} is a viable tool for assessing hydration status, it may have been beneficial to monitor other hydration indices in addition to this in order to gain further insight. Further assessments that could be used for future investigation could include body water loss per practice, electrolyte concentration (Maughan et al., 2004), sweat concentration (Williams & Blackwell, 2012), and the quantification of heat related symptoms in reference to hydration status.

Chapter 2

Literature Review

Review of Literature

Importance of Water for Life

Despite its molecular simplicity and abundance, water is perhaps the most essential nutrient for the health and sustenance in the human body. Anatomically, water accounts for approximately 50-60% of an individual's body mass. Lean tissue contains approximately 75% of water by mass; whereas adipose tissue contains approximately 5% (Jeukendrup & Gleeson, 2004). In addition to water's contribution to mass, it also provides the principle medium for multiple physiological functions such as: cellular homeostasis; metabolism; maintaining blood volume; thermoregulation; and physical performance (Popkin et al. 2010). Considering its importance, appropriate water intake guidelines have been proposed to help individuals sustain a healthy water balance. The Food and Nutrition Board, at the Institute of Medicine, recommends a daily adequate intake value of 3.7L and 2.7L for males and females respectively (Institute of Medicine, 2005). The World Health Organization supports this claim of importance and states that at minimum, individuals should ingest at least an amount in which equals that of water loss (WHO, 2005). Despite the necessity of water, studies have reported large percentages of certain populations failing to meet recommendations. For instance, Drewnowski et al. (2013), using data from 2005-2010 National Health and Nutrition Examination Survey (NHANES), reported that 83% of women and 95% of men aged ≥71 years, failed to meet recommendations. Similarly, a study conducted by Kenney et al. (2015), whilst looking at NHANES data from 2009-2012, also found that 54.5% of children aged 6-19 years were habitually inadequately hydrated.

Water Balance

The term "water balance" represents the net difference between water intake and water loss (Sawka & Coyle, 1999). When an individual sustains total body water and prevents water loss via the ingestion of sufficient fluids, they are said to be within a *euhydrated* state; this state is ideal for all individuals. In spite of this, however, an individual can experience *hyperhydration* if they were to ingest excessive amounts of water. A decrease in total body water is suggestive of *dehydration* or *hypohydration*, which signifies greater water loss than water ingestion. The current scientific consensus is that a state of dehydration can be characterized by a loss of body mass of ≥2% (Murray, 2007). Certain studies argue what constitutes the onset of dehydration, with evidence supporting the thirst mechanism triggering at a deficit of as low as 1% (Sawka & Pandolf, 1990; Shirreffs, 2005). Although the exact threshold of dehydration is unclear, with further research being required for individual differences, the detrimental effects of dehydration are clear. Dehydration can lead to cardiovascular impairment, renal impairment, weakness and lassitude, dizziness, and nausea (Maughan, 2003). In addition, dehydration weakens the body's thermoregulatory ability (Montain & Coyle, 1992); can produce disruptions in mood and cognitive functioning (Cian et al., 2000); can increase the prevalence of kidney stone formation (Embon et al., 1990); and in more extreme cases could be related to a heightened risk of developing varying cancers (Altieri et al., 2003).

Water loss is inevitable throughout the day and occurs through varying mechanisms. Some of the most common physiological avenues in which water is lost include urine, faeces, from the lungs during respiration, losses through the skin via sweat glands, and the process of thermoregulation (Maughan, 2003). It is important to understand that individual daily water loss will vary greatly in respect to variables such as age, sex, environmental factors (humidity and temperature), and activity level. Internal thermoregulatory mechanisms continuously work to sustain normal resting core temperatures of about 37 ^{o}C. which is optimal for cellular functions to operate most proficiently (Gisolfi & Mora, 2000). During physical exertion, metabolic heat production can increase substantially, with only a small percentage of this heat being converted into mechanical energy (Sawka & Wenger, 1988). With an increase in internal heat, and a need for core temperatures to stay as stable as possible, the body must work to dissipate this heat (Lim et al., 2008). One primary mechanism of excess heat expulsion from the body is through perspiration, more commonly known as sweating. The human body is covered in millions of sweat glands which produce and excrete a liquid formula, simply known as sweat, in an attempt to aid the removal of excess body heat. As sweat is excreted onto the skins surface, providing environmental factors are appropriate, it will evaporate taking with it surface heat. One liter of sweat, if perfectly evaporated, can dissipate about 580 calories of heat (Williams et al., 2017). Sweat is a combination of water, sodium chloride (salt), and some potassium (Huang et al., 2002), with water being the principle base. An increase in sweat rate therefore has been scientifically connected to an increase in water loss and ultimately the development of dehydration (Sawka & Montain, 2000; Bates & Miller, 2008).

Assessment of Hydration Status

With such a multitude of adverse conditions being related to water imbalances, being able to distinguish and identify whether an individual is in a state of dehydration is vital. Measuring hydration status can be done through various field or laboratory methods. An example of a field measure that can be used by any individual to evaluate hydration status is urine color. Urine is a combination of water and solutes such as sodium, potassium, dissolved ions, and other in/organic compounds. When large volumes of urine are excreted, it is suggestive of an abundance of water; the urine is diluted. This gives a visual pale color. Conversely, if smaller volumes of urine are excreted then there is less water content; the urine is concentrated. This gives a visual dark color. Color charts are available to compare and determine hydration status, with a pale-yellow color representing a preferred euhydrated state (Casa et al., 2000). Although using urine color as a hydration assessment tool is often criticized for its lack of reliability and validity (Baron et al., 2015), some studies argue that its ease-of-use and application remain a strong case for its use in research (Kavouras et al., 2016; Armstrong et al., 1994). In addition to urine color, assessing changes in body mass is also a common field measure; however, this is typically used when looking at specific events or time periods. This is due to how body weight is influenced by factors other than hydration (Baron et al., 2015). For example, if a researcher was curious to know how graded dehydration influenced maximal heart rate, dehydration is usually set at a percent loss of body mass. As previously stated, in most cases a state of dehydration is characterized by an individual body mass loss of ≥2%.

Despite field measurements often being noninvasive and cost effective, the level of subjectivity and variability involved creates grounds for skepticism. With reliability and validity being important foundations for any research study, it is crucial to control as many variables as possible without physically influencing the outcome. With control being imperative, measurement techniques are most effective in a laboratory setting. Assessing hydration status in a laboratory setting (in which postural, activity, dietary, and environmental factors are controlled) allows total body water, volume of fluids, concentration, and compartmentalization to stabilize (Armstrong, 2007). This therefore provides an opportunity for an objective measurement of hydration status. Regardless of this, however, scientific methods often come with heightened cost, required knowledge and expertise, limited accessibility, and invasiveness. These are all important aspects to consider when choosing which technique is best suited to the hypothesis and proposed aim of a study. General comparative characteristics for multiple hydration assessment techniques can be found in Table 1.

The simplest laboratory technique for assessing hydration is analyzing urine specific gravity (U_{sg}). Arguably a field technique due to its increased portability and ease of use, U_{sg} can be assessed using a refractometer. U_{sg} looks at the density of an individual's urine in comparison to distilled or deionized water. The National Collegiate Athletic Association (NCAA) has proposed a U_{sg} value of $\geq$1.020 as being indicative of significant dehydration (Casa et al., 2000). The use of U_{sg} as a tool for predicting hydration status has been noted in numerous studies, suggesting its preference over other techniques (Stover et al., 2006; Gibson et al., 2012; Phillips et al., 2014). Conversely, though, arguments about the accuracy, sensitivity, and lack of correlation with other methods have been made (Sommerfield et al., 2016). A further laboratory technique which uses expelled urine is osmolality (U_{osm}). Osmolality looks at the concentration of osmotic solutes, for example sodium, potassium and urea, present in an individual's urine sample. U_{osm} is dependent upon 2 parameters (quantity of solutes and water) and is measured using a freezing-point or vapor pressure-depression osmometer, a tool which is relatively expensive and requires a permanent site for operation and testing. Despite being the somewhat "happy medium" of laboratory techniques, the agreement on thresholds for defining hydration status remains dubious. Cleary et al. (2012) used a cut off value of 700 mOsm/L, whereas Grant & Kubo (1975) stated anything above 1000 mOsm/L shows dehydration. This broad range of cut off values makes it hard to conclusively state whether an individual is indeed dehydrated or not, and therefore affects the reliability of this measurement technique. Further research is needed to narrow these threshold ranges (Cheuvront et al., 2016). Another measurement often used as a marker for hydration is plasma osmolality (P_{osm}). Similar to U_{osm}, P_{osm} measures the body's electrolyte-water balance. The major difference however is how P_{osm} looks at intracellular water content via extracting a blood sample from an individual. This more direct measurement of cellular hydration is just one reason as to why P_{osm} is considered the current "gold standard" (Armstrong, 2007). Due to the neuroendocrine regulation of plasma osmolality, normative values rarely deviate from a healthy state of approximately 287 mOsm/kg. This meticulous regulation makes abnormalities easy to identify. P_{osm} is presently considered the "gold standard" measurement of hydration considering its enforced level of accuracy (Popowski et al., 2001; Armstrong, 2007); however, the need of a blood sample, suitable storage, expensive laboratory equipment, and skill often limits its use to only larger, well-funded, clinical settings (Seifarth et al., 2005; Sweeney & Beuchat, 1993).

Table 1 – various methods of hydration assessment

Assessment Technique	Field/Laboratory	Measured Variables	Thresholds [a]	Validity [b]	Practicality [c]
Isotope Dilution	Laboratory	TBW content	≥2% change in TBW	***	$$$; not portable
Body Mass Change (acute context)	Field	Body water loss or gain ± kg	≥2% of body weight indicates dehydration	*	$; portable via moveable scales
Plasma Osmolality	Laboratory	Extracellular fluid concentration[e]; mOsm/kg of water	Euhydration set-point of ~285 mOsm/kg	***	$$$; not portable
Urine Osmolality (U_{osm})	Laboratory	Urine concentration[e]; mOsm/kg of water	>700 mOsm/kg indicative of dehydration[2]	**	$$$; not portable
Urine Specific Gravity (U_{sg})	Field/Laboratory	Density of urine against the density of deionized water	†Indexes of Hydration Status	**	$ - $$; portable via hand-held spectrometer
Urine Color	Field	Urochrome[d] concentration	1-8 Scale; hydrated - dehydrated respectively[1]	*	$; portable
24-hour Urine Volume	Field	Daily flow rate; total urinary excretion	N/A	*	$; portable
Saliva Flow Rate and Osmolality	Laboratory	Flow rate (ml/min); mOsm/kg of water	↓ saliva rate; ↑ salvia osmolality[3] >76 mOsm/L	**	$$; moderate portability
Perceived Thirst	Field	Perception based on extracellular fluid	N/A	*	$; portable

[a] *thresholds* referring to the cut off points which are indicative of dehydration

[b] *accuracy* referring to the techniques proposed conformity to the actual (true) value. * = low; ** = moderate; *** = high

[c] *practicality* in regards to portability and cost effectiveness. $ = little; $$ = moderate; $$$ = high

[d] urochrome is a product of the liver and is the pigment found in urine that causes the visualization of color; usually a pale yellow

[e] concentration of osmotic solutes found in the plasma/urine

[1] in reference to the Armstrong et al. 1998 color chart

[2] Oppliger et al. (2005); Cleary et al. (2012) set points; however other studies propose slightly varying cut-off values

[3] Sawinski et al. (1966)

† Casa et al. (2000): Hydrated = <1.010; Minimal Dehydration = 1.010-1.020; Sig. Dehydration = 1.021-1.030; Serious Dehydration = >1.030

TBW = total body water

N/A in that perceived thirst and total excreted urine in 24-hour will vary greatly between every individual and influenced by numerous variables

Prevalence of dehydration and impact on sports performance

Given the vigorous nature of sports, and the underlying relationship between sweat rate and water loss, athletes are consequently at a much greater risk than many for the development of dehydration. With sporting, active movements result in higher rates of metabolic heat production (via increased muscular contractions), and this leads to a proportional elevation in body temperature, sweat rate, and water loss (Maughan et al., 2004). In addition to the common adverse effects of dehydration, athletes can often experience further, performance specific, repercussions. Dehydration has been found to impair cardiovascular functioning; with noticeable influences on heart rate, core body temperature and rate of perceived exertion. A seminal study by Montain & Coyle (1992), looking at the impact of graded dehydration on cardiovascular drift, found that the increase in heart rate and core temperature was proportional to the extent of dehydration. Similar responses were found by Coyle (1998) as heart rate, core temperature, and perceived exertion increased over time during a progressive dehydration cycling trial. Muscular power, or the ability to generate force, has also been found to be impacted by levels of dehydration. Jones et al. (2008), found that following an upper and lower Wingate anaerobic test in both a euhydrated (±1% body mass) and dehydrated (-3% body mass) state, power output was significantly compromised by dehydration.

Correspondingly, Webster et al. (1990) found that college wrestlers, following common weight loss regimes that resulted in induced dehydration, had a negative impact on anaerobic power and anaerobic capacity. Although research into the effects of dehydration on endurance performance is inconclusive, Kenefick et al. (2002) did find during a 4 minute graded treadmill test (modified Astrand protocol) that performing in a dehydrated state (- 4% body mass) resulted in an earlier lactate threshold spike. Further research has also found a relationship between hydration status and cognitive functioning. Smith et al. (2012) compared the results of a golf-specific motor and cognitive performance task performed by players in both a euhydrated and dehydrated (- 1.5% body mass) state. It was found that even mild dehydration significantly impaired motor (shot distance and accuracy), and cognitive performance (error in distance judgment). A comprehensive overview of studies, compiled by Grandjean & Grandjean (2007), concluded that a loss in body mass of as little as 2% can cause decrements in visuomotor, psychomotor and cognitive performance.

In dispute, some research has found a lack of relationship between hydration status and sporting performance. For example, Cheung et al. (2015) found that neither lowered hydration nor perceived thirst had a significant effect on power output or pacing during a 20-km cycling trial. Additionally, Greiwe et al. (1998) found that dehydration of 4% body mass did not affect isometric strength or endurance of knee extensors and elbow flexors. Despite these discrepancies, though, the general consensus remains that dehydration does pose a threat to physiological and performance related variables (Goulet, 2013; Shirreffs, 2005; Maughan, 2003; Nichols et al., 2005).

Professional bodies, such as the American College of Sports Medicine (ACSM) and the National Athletic Trainers' Association (NATA), have position stands claiming the importance of education and maintenance of water balance in all individuals, specifically athletes (Sawka et al., 2007 ACSM position stand; Casa et al., 2000 NATA position statement). Although fluid replacement guidelines are readily available, specific emphasis should be made on individualizing fluid replacement per athlete over the application of a generalized replacement amount (Lopez, 2012; Casa et al., 2000). However, the question of just how prevalent is dehydration amongst athletes preparing to engage in training or competition requires further examination. Approaching training and competition in any sub-optimal state will increase the demands of training and competition, increase perceived effort, and perhaps increase the risk of injury or illness on the athlete (Thompson et al. 2016 ACSM position stand "Nutrition and Athletic Performance").

Given the concerns regarding dehydration and athletes, multiple studies have looked at the prevalence of dehydration in this population. Sawka et al. (2007), using a multitude of resources, compiled a table of observational data looking at hydration factors of common sports. It was found that sweat rate was highest in tennis (2.60 L·h); whereas percent of dehydration (% loss in BM) was greatest in soccer (1.62% BM). Arnaoutis et al. (2015) found whilst studying 59 young-elite male athletes, from varying sports, that 89% of all athletes were dehydrated before even beginning physical activity ($U_{sg} \geq 1.020$). Additionally, an average body mass loss of 1.1% was found across sports. A large scale study conducted by Volpe et al. (2009) at a NCAA Division 1 school, looked at the pre-practice hydration status of 263 athletes across 14 sports. Using U_{sg} to assess hydration, it was found that 13% of athletes were significantly dehydrated; 53% appeared dehydrated; and 34% were suitably euhydrated.

Prevalence of dehydration and impact on soccer performance

Though the prevalence of dehydration is marked among athletes, certain sports have greater physiological demands than others. In particular, soccer is a sport with significant environmental, physiological, and psychological stressors. According to the Fédération Internationale de Football Association (FIFA), the global governing body of football or "soccer", it is estimated that over 265 million males and females participate in this sport around the world ("Big Count" FIFA Survey 2006). With men's and women's soccer also being predominant in both NCAA and National Association of Intercollegiate Athletics (NAIA) schools, the number of athletes to account for in this sport alone is vast. Soccer is characterized as being a high intensity, intermittent form of exercise (Ekblom, 1986). Taking into consideration the length of an average game (2 x 45 minute halves), soccer is argued as being primarily endurance driven; calling on aerobic systems for energy metabolism (Bangsbo, 1994). However, with the inclusion of sprints, tackles, kicking, jumping and other explosive and agile movements, soccer is generally noted as being a combination of both aerobic and anaerobic pathways (Reilly, 1997; Stølen et al., 2006). Although soccer varies in intensity depending position and performance level, average work rate of an outfield player has been found to be ~70-80% of one's VO_{2max} (Bangsbo, 1994; Āstrand et al., 2003). Heart rate max (HR_{max}) is another commonly tested variable in soccer, with research predicting an average game intensity ranging from 80-90% of $HR_{max,}$ dependent on position (Alexandre et al., 2012; Billows et al., 2005; Strøyer et al., 2004). With advances in global positioning systems (GPS), recent research has also begun to look at average distance covered during a game. Di Salvo et al. (2007) found that, independent of position, the mean total distance ($\bar{x}$ ± SD) covered by players was 11393 ± 1016 meters. Similar studies support Di Salvo's findings, further claiming that in positional terms midfielders cover the greatest distance per game (Bradley et al., 2009; Bloomfield et al., 2007).

With the physiological and metabolic demands of soccer being extensive, core body temperature elevations are inevitable (Edwards & Clark, 2006). With core temperatures reaching up to 39^{o}-40^{o}C during match play (Maughan & Leiper, 1994), efficient thermoregulation is needed to prevent overheating. Sweating is the body's primary response for expelling excess body heat; however, the efficiency of this can be influenced by environmental factors. With soccer often being played outside, the surrounding ambient temperature and humidity can inhibit the ability for the body to cool itself in an effective manner. This can lead to a multitude of heat illnesses, some of which may be life threatening. A Wet-Bulb Globe Temperature (WBGT) of higher than 28^{o}C is suggestive of a dangerous environment to play in, and activity in this heat requires careful monitoring (NCAA Sports Medicine Handbook 2013-14). Elevated core temperatures, whether environmentally influenced or not, consequently leads to the initiation of a greater sweating response. This increase in sweat rate may generate a greater net water loss unless water is replaced via sufficient fluid intake (Edwards & Noakes, 2009). All in all, taking into consideration the vast physiological and environmental stresses placed upon soccer players, their water needs are heightened which makes hydration monitoring and knowledge extremely important.

Phillips et al. (2014) found whilst monitoring elite soccer players over 3 consecutive training sessions that players experienced a decrease in body mass every session with the greatest decrease being observed as 1.54%. It was additionally found that 77% of participants on day 1 and 3, and 62% on day 2, were in a state of dehydration before practice, as determined by U_{sg} values of >1.020. A similar study by Castro-Sepulveda et al. (2016) monitored the hydration status of 17 elite female soccer players before three varying events: training (PT), friendly match (PF), and an official game (PO). It was found that dehydration was prevalent prior to every event (U_{sg} levels: PT = 1.029; PF = 1.023; PO = 1.030) and that an average of 47.05% of players were severely dehydrated (U_{sg} >1.030). Guttierres et al. (2011) found similar results after determining the hydration status of 20 soccer players prior to a competitive game. Mean pre-game U_{sg} was 1.023 ± 6 g·ml, suggesting that the majority of players were entering the game already in a dehydrated state. Additionally, Gibson et al. (2012) found comparable results after monitoring the hydration status of 34 female Canadian elite soccer players before 2 training sessions, separated by a week. Over both sessions it was found that 45.4% of players presented to training in a dehydrated state (U_{sg} >1.020); 40.9% were significantly dehydrated (U_{sg} 1.020-1.029); and 4.5% were seriously dehydrated (U_{sg} >1.030). A further study by Ersoy et al. (2016) used U_{sg} and U_{osm} to look at the hydration status of 26 young male soccer players 3 days prior to an important competition. With mean U_{sg} values of 1.021 ± 4, and mean U_{osm} values of 903 ± 133 mOsm/kg, it was concluded that these youth players were at risk for being dehydrated. However, comparing these values to guidelines from other sources it could be argued that players were already in a dehydrated state (U_{sg} >1.020; U_{osm} >700). Finally, Silva et al. (2011) investigated pre-training hydration status of 20 elite Brazilian soccer players on 3 consecutive days. Akin to other findings, it was found that players began every training day in a mildly dehydrated state (mean U_{sg} >1.020 each day). More information, and results from these and similar studies, are displayed in Table 2.

Table 2: Studies examining hydration in athletes related to training and competition

Study	Subjects	Methods	Results	Notes
Decher et al. (2008)	67 active youth (M=57; F=10) (ages; 12 ± 3)	4 day sports camp Pre-AM practice; Post-PM practice U_{sg} and U_{osm}	Mean Pre-AM and Post-PM U_{sg} ranged from minimal to sig. dehydration every day (U_{sg} 1.020 – 1.029)	Baseline U_{osm} values also indicated dehydration upon entering camp (880 ± 261)
MacLeod & Sunderland (2009)	16 elite female hockey players (ages; 19 ± 1 years)	2 match analysis (Game 1; Game 2) Pre-match U_{osm} collected	Game 1 U_{osm} = 197 ± 110 Game 2 U_{osm} = 425 ± 206 No players attended in a Hypohydrated state	> 900 mOsm/kg indicated hypohydration
Osterberg et al. (2009)	29 professional NBA basketball players	2 game days; 2 to 4 days apart Pre-game U_{sg}	52% players U_{sg} >1.020 Pre-game 1 U_{sg} ($\bar{x} \pm SD$) = 1.020 ± 0.006 Pre-game 2 U_{sg} U_{sg} ($\bar{x} \pm SD$) = 1.019 ± 0.008	Poor Pre-game hydration status (dehydrated)
Volpe et al. (2009)	263 NCAA D1 college athletes (138 male; 125 female) (ages; 19.9 ± 1.3 years) 14 varying sports	1 day pre-practice sample 3 hydration groups: *Euhydrated*[1]; *Hypoydrated*[2]; *Significantly Hypohydrated*[3]	34% Euhydrated 53% Hypohydrated 13% Significantly Hypohydrated	Chi-squared analysis All in all, at least 66% were Hypohydrated
Guttierres et al. (2011)	20 junior soccer players (ages; 17.9 ±1.3 years) 8 DF; 8 MF; 4 F	1 day analysis Pre & Post Match U_{sg}	Pre-Match U_{sg} ($\bar{x} \pm SD$) = 1.023 ± 6 $g \cdot ml^{-1}$ Post-Match U_{sg} ($\bar{x} \pm SD$) = 1.027 ± 6 $g \cdot ml^{-1}$	Both Pre and Post match mean U_{sg} values indicated significant dehydration (1.021 – 1.030 $g \cdot ml^{-1}$)
Silva et al. (2011)	20 adolescent soccer players (ages; 17.2 ± 0.5 years)	3 consecutive days Pre & Post-training U_{sg}	Mean Pre-training U_{sg} of >1.020 on all days	U_{sg} 1.020 cut off for adequate hydration
Brandenburg & Gaetz (2012)	17 elite female basketball players (ages; 24.2 ± 3 years)	2 consecutive game days Pregame hydration status via U_{sg}	Game 1 U_{sg} ($\bar{x} \pm SD$) = 1.005 ± 0.002 Game 2 U_{sg} ($\bar{x} \pm SD$) = 1.010 ± 0.005	Overall low incidence of pregame dehydration
Gibson et al. (2012)	34 junior elite female soccer players (ages; 15.7 ± 0.7 years)	2 training sessions; separated by 7 days Pre-training U_{sg} collected	45.4% U_{sg} >1.020 40.9% U_{sg} 1.020 - 1.029 4.5% U_{sg} >1.030	Combined U_{sg} $\bar{x} \pm SD$ = 1.018 ± 0.009

Phillips et al. (2014)	14 male soccer players (ages; 16.9 ± 0.8 years)	3 consecutive training sessions Morning, Pre & Post-practice U_{sg} collected Hypohydrated = ≥1.020	77% were Hypohydrated upon waking on Day 1 and 3; 62% on Day 2	No significant difference in U_{sg} between waking and Pre & Post-practice
Arnaoutis et al. (2015)	59 elite male athletes 5 varying sports (ages; 15.2 ± 1.3 years)	1 training day Morning, Pre & Post-practice U_{sg} collected Dehydrated = U_{sg} ≥1.020	89.8% athletes were Hypohydrated (Morning) 76.3% athletes were Hypohydrated (Pre-practice)	High prevalence of hypohydration across different sports
Gordon et al. (2015)	79 male adolescent soccer players (ages; 15.9 ± 0.8 years)	2 training sessions (TS1/TS2); 2 days apart Pre & Post-training U_{sg}	Pre-training U_{sg} ($\bar{x} \pm SD$) = 1.023 ± 0.005 Post-training U_{sg} ($\bar{x} \pm SD$) = 1.024 ± 0.006 ; indication of dehydration	19% on TS1 and 28% TS2 started training extremely dehydrated. Sig. few were hydrated Pre & Post practice.
Castro-Sepulveda et al. (2016)	17 international level female soccer players (ages; 21.5 ± 3 years)	3 sporting events (training, friendly game, official game) Prior event U_{sg}	47.05% severely dehydrated 33.33% significantly dehydrated 17.64% minimally dehydrated	Results averaged over 3 events
Ersoy et al. (2016)	26 male youth soccer players (ages; 15 ± 1.2 years)	2 days of analysis (U_{sg}, U_{osm}); 3 days prior to competition. Morning urine sample taken before breakfast	U_{sg} ($\bar{x} \pm SD$) 1.021 ± 4 Min – Max = 1.015 – 1.026 Athlete's under risk of dehydration	High correlation between hydration analysis methods ($P < 0.05$)

U_{sg} = Urine Specific Gravity (g/cm^3) with refractometer. U_{osm} = Urine Osmolality (mOsm/kg).

DF = defenders. MF = midfielders. F = forwards.

Euhydrated[1] = U_{sg} < 1.020; *Hypohydrated*[2] = U_{sg} 1.020 – 1.029; *Significantly Hypohydrated*[3] = ≥ 1.030.

Conclusion

The consensus regarding hydration research in athletes is that dehydration around single games or practice sessions is relatively common at any given time. However, less evidence is available regarding hydration status over multiple practice sessions, competitions, weeks, or months of a competitive season exists. Having a more thorough understanding of habitual levels of hydration is important to allow the development of more effective intervention strategies, athlete education, and individual monitoring that would be beneficial in reducing the prevalence of dehydration and heat-related illnesses (Magee et al., 2016; Judge et al., 2016; Maughan & Shirreffs, 2010; Murray, 1996).

Chapter 3

Practical Applications & Conclusion

Practical Applications

One of the most vital practical findings of this study was the conformation that the vast majority of female players awoke and attended practice or games already in a dehydrated state; additionally, very little effort was given to express hydration attitudes or knowledge. While the effect of dehydration on sporting performance varies between individuals, neglecting to account for pre-event dehydration could augment existing dehydration levels and impair major physiological functions required in soccer. Therefore, to reduce this potential risk of impeded performance, monitoring hydration status should be recommended within teams. This practice could be put in place by assessing the first urine void of the morning, with athletic trainers using a simple U_{sg} portable refractometer to quickly inform players of their initial hydration status. Keeping an ongoing record of hydration status could also help identify those players most vulnerable or susceptible to dehydration, which could in turn help to implement individualized hydration plans. Identifying barriers to drinking and incorporating hydration education could also help to combat the issue of inadequate hydration knowledge and appropriate fluid consumption. Botsis & Holden (2015) found that out of 21 NCAA college coaches, the average score on a Sports Nutrition Questionnaire was a mere 55%, which is below the required passing score of >75%. Implementing hydration education for both coaches and players could help improve baseline knowledge and fundamental understanding of the importance of hydration. Additionally, incorporating hydration interventions could also help to improve hydration status. In a study by Stover et al. (2006), in which athletes were provided with two 591-mL bottles of fluid to consume between dinner and bed time and upon waking, U_{sg} was significantly improved in comparison to pre-intervention U_{sg}. Kavouras et al. (2012) found similar improvements to an athlete's hydration status and endurance ability after the implementation of a fluid intervention. Ninety-two young athletes were assigned to intervention (INT) or control (CON). Sixty-one athletes attended an intervention seminar on hydration, were exposed to urine charts and allowed to ingest fluid ad libitum; the 32 remaining athletes had no hydration intervention. It was found that both hydration status (U_{sg}) and endurance ability improved significantly in the INT group. The results from our study and these studies combined ultimately highlight the importance of monitoring hydration in athletes, and the benefits a simplistic intervention or educational session could have on an athlete's hydration.

Conclusion

In conclusion, the current study found that dehydration was the most prevalent hydration state in college female soccer players upon waking and before practice or games in warm, in-season, field conditions. The highest incidences of dehydration were found in the morning, with U_{sg} values showing dehydration of all players on five out of the nine observed days. This prevalence of dehydration is consistent with previous observations of female soccer players (Castro-Sepulveda et al., 2016; Gibson et al., 2012), but over a longer period of time. Despite the lack of information gathered on knowledge towards hydration practices, after analysis of the BEVQ it was found that those who reportedly drank more fluids on a regular basis had lower U_{sg} values (more hydrated). Not only can dehydration negatively impact physiological, psychological, and skill related performance, it can also lead to an increased risk of injury or heat-related illness; therefore, those attending practice in a dehydrated state, risk sub-optimal performance. It is important for coaches and athletic staff to be aware of the importance of adequate hydration, to monitor hydration status of players and consider the implementation of hydration practices. These practices could in turn help to alleviate the incidence of pre-exercise dehydration.

REFERENCES

Adams, J.D., Kavouras, S.A., Johnson, E.C., Jansen, L.T., Capitan-Jimenez, C., Robillard, J.I., & Mauromoustakos, A. (2017). The effect of storing temperature and duration on urinary hydration markers. *International Journal of Sport Nutrition and Exercise Metabolism, 27* (1), 18-24.

Alexandre, D., Da Silva, C.D., Hill-Haas, S., Wong, D.P., Natali, A.J., De Lima, J.R.P.,… Karim, C. (2012). Heart rate monitoring in soccer: interest and limits during competitive match play and training, practical application. *Journal of Strength and Conditioning Research, 26* (10), 2890-2906.

Ali, A., Gardiner, R., Foskett, A., & Gant, N. (2011). Fluid balance, thermoregulation and sprint and passing skill performance in female soccer players. *Scandinavian Journal of Medicine and Science in Sports, 21* (3), 437-445.

Altieri, A., La Vecchia, C., & Negri, E. (2003). Fluid intake and risk of bladder and other cancers. *European Journal of Clinical Nutrition, 57* (2), S59-S68.

Armstrong, L.E., Maresh, C.M., Castellani, J.W., Bergeron, M.F., Kenefick, R.W., LaGasse, K.E., & Riebe, D. (1994). Urinary indices of hydration status. *International Journal of Sport Nutrition, 4* (3), 265-279.

Armstrong, L.E. (2007). Assessing hydration status: The elusive gold standard. *Journal of the American College of Nutrition, 26* (5), 575S-584S.

Armstrong, L.E., Ganip, M.S., Casa, D.J., Lee, E.C., McDermott, B.P., Klau, J.F.,… Lieberman, H.R. (2012). Mild dehydration affects mood in healthy young women. *Journal of Nutrition, 142* (2), 382-388.

Arnaoutis, G., Kavouras, S.A., Angelopoulou, A., Skoulariki, C., Bismpikou, S., Mourtakos, S., & Sidossis, L.S. (2015). Fluid balance during training in elite young athletes of different sports. *Journal of Strength and Conditioning Research, 29* (12), 3447-3452.

Astrand, P.O., Rodahl, K., Dahl, H.A., & Stromme, S.B. (2003). *Textbook of work physiology: Physiological bases of exercise (4th Edition)*. Champaign, IL: Human Kinetics.

Bangsbo, J. (1994). Energy demands in competitive soccer. *Journal of Sports Science,12,* S5-S12.

Baron, S., Courbebaisse, M., Lepicard, E.M., & Friedlander, G. (2015). Assessment of hydration status in a large population. *British Journal of Nutrition, 113* (1), 147-158.

Barr, S.I. (1999). Effects of dehydration on exercise performance. *Canadian Journal of Applied Physiology, 24* (2), 164-172.

Bates, G.P., & Miller, V.S. (2008). Sweat rate and sodium loss during work in the heat. *Journal of Occupational Medicine and Toxicology, 3* (4).

Billows, D., Reilly, T., & George, K. (2005). Physiological demands of match-play on elite adolescent footballers. In T. Reilly, J. Cabri, & A. Duarte (Eds.), *Science and Football V 1st Edition* (453-461). London, United Kingdom: Routledge.

Bloomfield, J., Polman, R., & O'Donoghue, P. (2007). Physical demands of difference positions in FA premier league soccer. *Journal of Sports Science and Medicine, 6* (1), 63-70.

Botsis, A.E., & Holden, S.L. (2015). Nutritional knowledge of college coaches. *Sport Science Review, 24* (3-4), 193-200.

Bradley, P.S., Sheldon, W., Wooster, B., Olsen, P., Boanas, P., & Krustrup, P. (2009). High-intensity running in English FA premier league soccer matches. *Journal of Sports Sciences, 27* (2), 159-168.

Casa, D.J., Armstrong, L.E., Montain, S.J., Rich, B.S.E., & Stone, J.A. (2000). National Athletic Trainers' Association Position Statement: Fluid replacement for athletes. *Journal of Athletic Training, 35* (2), 212-224.

Casa, D.J., DeMartini, J.K., Bergeron, M.F., Csillan, D., Eichner, E.R., Lopez, R.M.,… Yeargin, S.W. (2015). National Athletic Trainer's Association position statement: exertional heat illnesses. *Journal of Athletic Training, 50* (9), 986-1000.

Castro-Sepulveda, M., Astudillo, J., Letelier, P., & Zbinden-Foncea, H. (2016). Prevalence of dehydration before training sessions, friendly and official matched in elite female soccer players. *Journal of Human Kinetics, 50,* 79-84.

Cheung, S.S., McGarr, G.W., Mallette, M.M., Wallace, P.J., Watson, C.L., Kim, I.M., & Greenway, M.J. (2015). Separate and combined effects of dehydration and thirst sensation on exercise performance in heat. *Scandinavian Journal of Medicine and Science in Sports, 25* (1), 104-111.

Cheuvront, S.N., Ely, B.R., Kenefick, R.W., & Sawka, M.N. (2010). Biological variation and diagnostic accuracy of dehydration assessment markers. *American Journal of Clinical Nutrition, 92* (3), 565-573.

Cheuvront, S.N., Munoz, C.X., & Kenefick, R.W. (2016). The void in using urine concentration to assess population fluid intake adequacy or hydration status. *American Journal of Clinical Nutrition, 104* (3), 553-556.

Cian, C., Koulmann, N., Barraud, P.A., Raphel, C., Jimenez, C., & Melin, B. (2000). Influence of variations in body hydration on cognitive function: effect of hyperhydration, heat stress, and exercise-induced dehydration. *Journal of Psychophysiology, 14* (1), 29-36.

Cleary, M.A., Hetzler, R.K., Wasson, D., Wages, J.J., Stickley, C., & Kimura, I.F. (2012). Hydration behaviors before and after an educational and prescribed hydration intervention in adolescent athletes. *Journal of Athletic Training, 47* (3), 273-281.

Cometti, G., Maffiuletti, N.A., Pousson, M., Chatard, J.C., & Maffulli, N. (2001). Isokinetic strength and anaerobic power of elite, subelite and amateur French soccer players. *International Journal of Sports Medicine, 22* (1), 45-51.

Coris, E.E., Ramirez, A.M., & Durme, D.J.V. (2004). Heat illness in athletes: the dangerous combination of het, humidity and exercise. *Sports Medicine, 34* (1), 9-16.

Coyle, E.F. (1998). Cardiovascular drift during prolonged exercise and the effects of dehydration. *International Journal of Sports Medicine, 19* (2), S121-124.

Davis, J.A., Brewer, J., & Atkin, D. (1992). Pre-season physiological characteristics of English first and second division soccer players. *Journal of Sports Sciences, 10* (6), 541-547.

Decher, N.R., Casa, D.J., Yeargin, S.W., Ganio, M.S., Levreault, M.L., James, C.T.,… Brown, S.W. (2008). Hydration status, knowledge, and behavior in youths at summer sports camps. *International Journal of Sports Physiology and Performance, 3* (3), 262-278.

Di Salvo, V., Baron, R., Tschan, H., Calderon Montero, F.J., Bachl, N., & Pigozzi, F. (2007). Performance characteristics according to playing position in elite soccer. *International Journal of Sports Medicine, 28* (3), 222-227.

Drewnowski, A., Rehm, C.D., & Constant, F. (2013). Water and beverage consumption amoung children age 4-13y in the United States: analyses of 2005-2010 NHANES data. *Nutrition Journal, 12* (85), 1-9.

Edwards, A.M., & Clark, N.A. (2006). Thermoregulatory observations in soccer match play: professional and recreational level applications using an intestinal pill system to measure core temperature. *British Journal of Sports Medicine, 40* (2), 133-138.

Edwards, A.M., Mann, M.E., Marfell-Jones, M.J., Rankin, D.M., Noakes, T.D., & Shillington, D.P. (2007). Influence of moderate dehydration on soccer performance: physiological responses to 45 min of outdoor match-play and the immediate subsequent performance of sport-specific and mental concentration tests. *British Journal of Sports Medicine, 41* (6). 385-391.

Edwards, A.M., & Noakes, T.D. (2009). Dehydration: cause of fatigue or sign of pacing in elite soccer? *Sports Medicine, 39* (1), 1-13.

Ekblom, B. (1986). Applied physiology of soccer. *Sports Medicine, 3* (1), 50-60.

Embon, O.M., Rose, G.A., & Rosenbaum, T. (1990). Chronic dehydration stone disease. *British Journal of Urology International, 66* (4), 357-362.

Ersoy, N., Ersoy, G., & Kutlu, M. (2016). Assessment of hydration status of elite young male soccer players with different methods and new approach method of substitute urine strip. *Journal of the International Soceity of Sports Nutrition, 13* (34), 1-6.

FIFA Big Count. 2006. *Statistical summary report by gender/category/region* [online]. Retrieved from https://www.fifa.com/mm/document/fifafacts/bcoffsurv/emaga_9384_10704.pdf

Garth, A.K., & Burke, L.M. (2013). What do athletes drink during competitive sporting activities? *Sports Medicine, 43* (7), 539-564.

Gibson, J.C., Stuart-Hill, L.A., Pethick, W., & Gaul, C.A. (2012). Hydration status and fluid and sodium balance in elite Canadian junior women's soccer players in a cool environment. *Applied Physiology, Nutrition, and Metabolism, 37* (5), 931-937.

Gisolfi, C.V., & Duchman, S.M. (1992). Guidelines for optimal fluid replacement beverages for different athletic events. *Medicine and Science in Sports and Exercise, 24* (6), 679-687.

Gisolfi, C.V., & Mora, F. (2000). *The Hot Brain: Survival, Temperature and the Human Body.* Massachusetts: MIT Press.

Goulet, E.D. (2013). Effect of exercise-induced dehydration on endurance performance: evaluating the impact of exercise protocols on outcomes using a meta-analytic procedure. *British Journal of Sports Medicine, 47* (11), 679-686.

Grandjean, A.C. (2005). Water requirements, impinging factors and recommended intakes. In WHO, *Nutrients in Drinking Water* (25-40). Geneva, Switzerland: World Health Organization.

Grandjean, A.C., & Grandjean, N.R. (2007). Dehydration and cognitive performance. *Journal of the American College of Nutrition, 26* (5), 549S-554S.

Grant, K.K., & Kubo, W.M. (1975). Assessing a patient's hydration status. *American Journal of Nursing, 75* (8), 1307-1311.

Greiwe, J.S., Staffey, K.S., Melrose, D.R., Narve, M.D., & Knowlton, R.G. (1998). Effects of dehydration on isometric muscular strength and endurance. *Medicine and Science in Sports and Exercise, 30* (2), 284-288.

Guttierres, A.P.M., Natali, A.J., Vianna, J.M., Reis, V.M., & Marins, J.C.B. (2011). Dehydration in soccer players after a match in the heat. *Biology of Sport, 28* (4), 249-254.

Hargreaves, M., Dillo, P., Angus, D., & Febbraio, M. (1996). Effect of fluid ingestion on muscle metabolism during prolonged exercise. *Journal of Applied Physiology, 80* (1), 363-366.

Hedrick, V.E., Savla, J., Comber, D.L., Flack, K.D., Eastabrooks, P.A., Nsiah-Kumi, P.A.,… Davy, B.M. (2012). Development of a brief questionnaire to assess habitual beverage intake (BEVQ-15): sugar-sweetened beverages and total beverage energy intake. *Journal of the Academy of Nutrition and Dietetics, 112* (6), 840-849.

Hedrick, V.E., Comber, D.L., Ferguson, K.E., Estabrooks, P.A., Savla, J., Dietrich, A.M.,… Davy, B.M. (2013). A rapid beverage intake questionnaire can detect changes in beverage intake. *Eating Behaviors, 14* (1), 90-94.

Huang, C.T., Chen, M.L., Huang, L.L., & Mao, I.F. (2002). Uric acid and urea in human sweat. *Chinese Journal of Physiology, 45* (3), 109-115.

Hunt, A.P., & Stewart, I.B. (2011). Field hydration assessment through urine analysis; effects of time delay and storage temperature. *Journal of Health, Safety and Environment, 27* (2), 139-144.

Institute of Medicine. (2005). *Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate* (73-185). Washington, DC: The National Academies Press.

Jeukendrup, A., & Gleeson, M. (2004). *Sport Nutrition: An introduction to energy production and performance.* Champaign, IL: Human Kinetics.

Jones, L.C., Cleary, M.A., Lopez, R.M., Zuri, R.E., & Lopez, R. (2008). Active dehydration impairs upper and lower body anaerobic muscular power. *Journal of Strength and Conditioning Research, 22* (2), 455-463.

Judge, L.W., Kumley, R.F., Bellar, D.M., Pike, K.L., Pierson, E.E., Weidner, T.,… Friesen, C.A. (2016). Hydration and fluid replacement knowledge, attitudes, barriers, and behaviors of NCAA division 1 American football players. *Journal of Strength and Conditioning Research, 30* (11), 2972-2978.

Kavouras, S.A., Arnaoutis, G., Makrillos, M., Garagouni, C., Nikolaou, E., Chira, O., Ellinikaki, E., & Sidossis, L.S. (2012). Educational intervention on water intake improves hydration status and enhances exercise performance in athletic youth. *Scandinavian Journal of Medicine and Science in Sports, 22* (5), 684-689.

Kavouras, S.A., Johnson, E.C., Bougtsas, D., Arnaoutis, G., Panagiotakos, D.B., Perrier, E., & Klein, A. (2016). Validation of a urine color scale for assessment of urine osmolality in healthy children. *European Journal of Nutrition, 55,* 907-915.

Kenefick, R.W., Mahood, N.V., Mattern, C.O., Kertzer, R., & Quinn, T.J. (2002). Hypohydration adversely affects lactate threshold in endurance athletes. *Journal of Strength and Conditioning Research, 16* (1), 38-43.

Kenefick, R.W., & Sawka, M.N. (2007). Heat exhaustion and dehydration as causes of marathon collapse. *Sports Medicine, 37* (4-5), 378-381.

Kenney, E.L., Long, M.W., Cradock, A.L., & Gortmaker, S.L. (2015). Prevalence of inadequate hydration among US children and disparities by gender and race/ethnicity: NHANES 2009-2012. *American Journal of Public Health, 105* (8), e113-e118.

Kilding, A.E., Tunstall, H., Wraith, E., Good, M., Gammon, C., & Smith, C. (2009). Sweat rate and sweat electrolyte composition in international female soccer players during game specific training. *International Journal of Sports Medicine, 30* (6), 443-447.

Kirkendall, D.T. (2007). Issues in training the female player. *British Journal Sports Medicine, 47* (1), i64-i67.

Klossner, D. (2013). *2013-14 NCAA Sports Medicine Handbook.* Indianapolis, IN: National Collegiate Athletic Association.

Leong Lim, C., Byrne, C., & Lee, J.K.W. (2008). Human thermoregulation and measurement of body temperature in exercise and clinical settings. *Annals Academy of Medicine Singapore, 37* (4), 347-353.

Lopez, R.M. (2012). Exercise and hydration: individualizing fluid replacement guidelines. *Strength and Conditioning Journal, 34* (4), 49-54.

Luliano, S., Naughton, G., Collier, G., & Carlson, J. (1998). Examination of the self-selected fluid intake practices by junior athletes during a simulated duathlon event. *International Journal of Sports Nutrition, 8* (1), 10-23.

Magee, P.J., Gallagher, A.M., & McCormack, J.M. (2016). High prevalence of dehydration and inadequate nutritional knowledge amount university and club level athletes. *International Journal of Sports Nutrition and Exercise Metabolism, 6,* 1-27.

Maughan, R.J., & Leiper, J.B. (1994). Fluid replacement requirements in soccer. *Journal of Sports Sciences, 12* (Special Issue), S29-34.

Maughan, R.J. (2003). Impact of mild dehydration on wellness and on exercise performance. *European Journal of Clinical Nutrition, 57* (2), S19-S23.

Maughan, R.J., Merson, S.J., Broad, N.P., & Shirreffs, S.M. (2004). Fluid and electrolyte intake and loss in elite soccer players during training. *International Journal of Sport Nutrition and Exercise Metabolism, 14* (3), 327-340

Maughan, R.J., & Shirreffs, S.M. (2010). Development of hydration strategies to optimize performance for athletes in high-intensity sports and in sports with repeated intense efforts. *Scandinavian Journal of Medicine and Science in Sports, 20* (2), 59-69.

McGregor, S.J., Nicholas, C.W., Lakomy, H.K.A., & Williams, C. (1999). The influence of intermittent high-intensity shuttle running and fluid ingestion on the performance of a soccer skill. *Journal of Sports Sciences, 17* (11), 895-903.

Montain, S.J., & Coyle, E.F. (1992). Influence of graded dehydration on hyperthermia and cardiovascular drift during exercise. *Journal of Applied Physiology, 73* (4), 1340-1350.

Murray, R. (1996). Dehydration, hyperthermia, and athletes: science and practice. *Journal of Athletic Training, 31* (3), 248-252.

Murray, R. (2007). Hydration and Physical Performance. *Journal of the American College of Nutrition, 26* (5), 542S-548S.

Nichols, P.E., Jonnalagadda, S.S., Rosenbloom, C.A., Trinkaus, M. (2005). Knowledge, attitudes, and behaviors regarding hydration and fluid replacement of collegiate athletes. *International Journal of Sports Nutrition and Exercise Metabolism, 15* (5), 515-527.

Oppliger, R.A., Magnes, S.A., Popowski, L.A., & Gisolfi, C.V. (2005). Accuracy of urine specific gravity and osmolality as indicators of hydration status. *International Journal of Sport Nutrition and Exercise Metabolism, 15* (3), 236-251.

Osterberg, K.L., Horswill, C.A., & Baker, L.B. (2009). Pregame urine specific gravity and fluid intake by national basketball association players during competition. *Journal of Athletic Training, 44* (1), 53-57.

Perrier, E., Demazieres, A., Girard, N., Pross, N., Osbild, D., Metzger, D.,… Klein, A. (2013). Circadian variation and responsiveness of hydration biomarkers to changes in daily water intake. *European Journal of Applied Physiology, 113* (8), 2143-2151.

Phillips, S.M., Sykes, D., & Gibson, N. (2014). Hydration status and fluid balance of elite European youth soccer players during consecutive training sessions. *Journal of Sports Science and Medicine, 13* (4), 817-822.

Poortmans, J.R. (1984). Exercise and renal function. *Sports Medicine*, *1* (2), 125-153.

Popkin, B.M., D’Anci, K.E., & Rosenberg, I.H. (2010). Water, Hydration and Health. *Nutrition Reviews, 68* (8), 439-458.

Popowski, L.A., Oppliger, R.A., Lambert, P., Johnson, R.F., & Gisolf, C.V. (2001). Blood and urinary measures of hydration status during progressive acute dehydration. *Medicine and Science in Sports and Exercise, 33* (5), 747-753.

Reilly, T. (1997). Energetics of high-intensity exercise (soccer) with particular reference to fatigue. *Journal of Sports Sciences, 15*, 257-263.

Rothenberg, J.A., & Panagos, A. (2008). Musculoskeletal performance and hydration status. *Current Reviews in Musculoskeletal Medicine, 1* (2), 131-136.

Sawka, M.N., & Wenger, C.B. (1988). Physiological responses to acute exercise-heat stress. In K.B. Pandolf, M.N. Sakwa, & R.R. Gonzalez (Eds.), *Human Performance Physiology and Environmental Medicine at Terrestrial Extremes* (1-38). Inianapolis, IN: Benchmark Press.

Sawka, M.N., & Coyle, E.F. (1999). Influence of body water and blood volume on thermoregulation and exercise performance in the heat. *Exercise and Sport Sciences Reviews*, *27*, 167-218.

Sawka, M.N., & Montain, S. (2000). Fluid and electrolyte supplementation for exercise heat stress. *American Journal of Clinical Nutrition, 72* (2), 564S-572S.

Sawka, M.N., & Pandolf, K.B. (2001). Effects of body water loss on physiological function and exercise performance. In C.V. Gisolfi, & D.R. Lamb (Eds.), *Perspectives in Exercise Science and Sports Medicine Vol. 3: Fluid homeostasis during exercise* (1-38). Transverse City, MI: Cooper Publishing Group

Sawka, M.N., Burke, L.M., Eichner, E.R., Maughan, R.J., Montain, S.J., & Stachenfeld, N.S. (2007). American College of Sports Medicine position stand. Exercise and fluid replacement. *Medicine and Science in Sports and Exercise, 39* (2), 377-390.

Seifarth, C.C., Miertschischk, J., Hahn, E.G., & Hensen, J. (2004). Measurement of serum and plasma osmolality in healthy young humans – influence of time and storage conditions. *Clinical Chemistry and Laboratory Medicine, 42* (8), 927-932.

Shirreffs, S.M. (2005). The importance of good hydration for work and exercise performance. *Nutrition Reviews, 63* (6), S14-S21.

Shirreffs, S.M., Aragon-Vargas, L.F., Chamorro, M., Maughan, R.J., Serratosa, L., & Zachwieja, J.J. (2005). The sweating response of elite professional soccer players to training in the heat. *International Journal of Sports Medicine, 26* (2), 90-95.

Silva, R.P., Mundel, T., Natali, A.J., Bara Filho, M.G., Lima, J.R.P., Alfenas, R.C.G.,… Marins, J.C.B. (2011). Fluid balance of elite Brazilian youth soccer players during consecutive days of training. *Journal of Sports Sciences, 29* (7), 725-732.

Smith, M.F., Newell, A.J., & Baker, M.R. (2012). Effect of acute mild dehydration on cognitive-motor performance in golf. *Journal of Strength and Conditioning Research, 26* (11), 3075-3080.

Sommerfield, L.M., McAnulty, S.R., McBride, J.M., Zwetsloot, J.J., Austin, M.D., Mehlhorn, J.D.,… Utter, A.C. (2016). Validity of urine specific gravity when compared with plasma osmolality as a measure of hydration status in male and female NCAA collegiate atheltes. *Journal of Strength and Conditioning Research, 30* (8), 2219-2225.

Stolen, T., Chamari, K., Castagna, C., & Wisloff, U. (2006). Physiology of Soccer: an update. *Sports Medicine, 35* (6), 501-536.

Stover, E.A., Zachwieja, J., Stofan, J., Murray, R., & Horswill, C.A. (2006). Consistently high urine specific gravity in adolescent American football players and the impact of an acute drinking strategy. *International Journal of Sports Medicine, 27* (4), 330-335.

Stroyer, J., Hansen, L., & Klausen, K. (2004). Physiological profile and activity pattern of young soccer players during match play. *Medicine and Science in Sports and Exercise, 36* (1), 168-174.

Sweeney, T.E., & Beuchat, C.A. (1993). Limitations of methods of osmometry: measuring the osmolality of biological fluids. *American Journal of Physiology, 264* (3), R469-R480.

Thomas, D.T., Erdman, K.A., & Burke, L.M. (2016). American College of Sports Medicine joint position statement. Nutrition and athletic performance. *Medicine and Science in Sports and Exercise, 48* (3), 435-568.

Volpe, S.L., Poule, K.A., & Bland, E.G. (2009). Estimation of prepractice hydration status of national collegiate athletic association division 1 athletes. *Journal of Athletic Training, 44* (6), 624-629.

Webster, S., Rutt, R., & Weltman, A. (1990). Physiological effects of a weight loss regimen practiced by college wrestlers. *Medicine and Science in Sports and Exercise, 22* (2), 229-234.

West, B.T., Welch, K.B., & Galecki, A.T. (2015). *Linear Mixed Models: A Practical Guide Using Statistical Software* (2nd Ed.). Boca Raton, FL: CRC Press, Taylor & Francis Group.

Williams, C.A., & Blackwell, J. (2012). Hydration status, fluid intake, and electrolyte losses in youth soccer players. *International Journal of Sports Physiology and Performance, 7* (4), 367-374.

Williams, M.H., Rawson, E.S., & Branch, J.D. (2017). *Nutrition for Health, Fitness & Sport: Eleventh Edition.* New York, NY: McGraw-Hill.

Wisloff, U., Helgerud, J., & Hoff, J. (1998). Strength and endurance of elite soccer players. *Medicine and Science in Sports and Exercise, 30* (3), 462-467.

APPENDICIES

APPENDIX A

- Informed Consent

Auburn University at Montgomery – Department of Kinesiology

INFORMED CONSENT
Concerning Participation in a Research Study

"Hydration Knowledge and Habitual Practices of Female Collegiate Athletes in Training and Competition"

You are invited to participate in a study of the knowledge, attitude and habitual characteristics of hydration levels in elite female collegiate athletes during training and competition periods.

Research Purpose & Procedures:

We hope to identify the current hydration knowledge in female collegiate athletes and whether they consider it important to their health and sport. Secondly, we will hope to identify the day-by-day habitual hydration status of athletes over a 2-week in-season period. You were selected as a possible participant because you meet the following justifying criteria:

- Female
- Over the age of 19
- Currently enrolled in a college institution
- A collegiate athlete
- Eligibly competing in 2016/17 sporting season
- Have no underlying medical contraindications as assessed by a health history questionnaire.

If you decide to participate, Holly Clarke (AUM graduate student in Kinesiology) as the Primary Investigator of this study will first meet to inform you on the methods and purpose of the study in hand. Once a full "Healthy History Questionnaire" has been completed and you are medically cleared for participation, you will be given a 2-week supply of urine sample cups and an initial "Hydration Knowledge" questionnaire to complete. The questionnaire and healthy history forms should not take any longer than 15 minutes to complete. Throughout the proposed dates, as discussed during the debriefing, you will be asked to collect a urine sample both in the morning upon waking (AM), and a further sample 0-1 hours before afternoon practice or competition. Samples will be collected by Holly Clarke at the designated site which will be discussed with you. All samples will be monitored and accessible only to those researchers who are named cleared in the final IRB. Upon completion of the 2-week sample collection period, all samples will be analyzed. Final conclusions and individual findings will be shared with you if you so wish, however no confidential information about any other participant will be shared. Upon ending this study, all samples and identifiable information will be destroyed.

Participation will be completely voluntary with zero adverse effects if participation is rejected or discontinued, or if personal information is asked to be withdrawn mid-study. There will be no repercussions or effect on your personal or athletic status.

Risks or Discomforts/Potential Benefits:

- There will be no physical discomforts involved with this study.
- Any concerns of "Breach of Confidentiality" will be addressed by keeping all information secure and confidential, with access only to those researchers who have current CITI training and who are named on the approved IRB.
- All data will be kept securely in the Auburn University at Montgomery Human Performance Laboratory; accessible only by key.
- Upon completion of said study, all information will be destroyed
- Participants will NOT be coerced into participating. Withdrawal from this study is allowed at any point, and comes with zero repercussions.
- Participants can benefit from this study by gaining knowledge and insight on the importance of hydration and their personal hydration habits and routine.
- With research showing hydration levels having a profound impact on sporting performance, another possible benefit to athletes could be seen in their sporting ability, endurance and recovery.
- However, we cannot promise you that you will receive any or all of these benefits.

Provisions for Confidentiality:

Any information obtained in connection with this study that can be identified with you will remain confidential and will be disclosed only with your permission. If you give us your permission by signing this document, information will only be used by approved researchers and investigators during data analysis. Once analysis has been completed, data will not be presented in any way in which individuals can be identified directly. Upon completion of the study, all personal and identifiable information will be shredded and discarded sufficiently.

Contacts for Additional Information:

Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind now. Later, if you have questions about the study, you can contact the investigator, Holly Clarke, at hclarke@aum.edu or 334-333-7068. If you have any questions about your rights as a volunteer in this research, contact Debra Tomblin, Research Compliance Manager, AUM, 334-244-3250, dtomblin@aum.edu.

Voluntary Participation & the Right to Discontinue Participation without Penalty:

If you decide to participate, you are free to withdraw your consent and to discontinue participation at any time without penalty. If you decide later to withdraw from the study, you may also withdraw any information that has been collected about you. Your decision whether to participate will not prejudice your future relations with Auburn University at Montgomery or Faulkner University. The researcher may discontinue the study at any point. The researcher may terminate your participation from the project at any point.

We will give you a copy of this consent form to take with you.

YOU ARE MAKING A DECISION WHETHER TO PARTICIPATE. YOUR SIGNATURE INDICATES THAT YOU HAVE DECIDED TOPARTICIPATE, HAVING READ THE INFORMATION PROVIDED ABOVE.

Participant’s signature & Date

___________________ ______________________________________

Investigator's signature

____

APPENDIX B

- Health History Questionnaire

Health & Fitness Assessment at *AUBURN MONTGOMERY*

HEALTH & LIFESTYLE HISTORY QUESTIONNAIRE

Please complete this form (2 pages front and back) as accurately as possible. The information you provide will be used to evaluate your health by the physician or exercise physiologist who will see you in our facility.

All information you provide will be treated as privileged and confidential.

1. IDENTIFICATION & GENERAL INFORMATION

Name				Today's Date	
				/ /	
Age	Date of Birth	Gender		Occupation	
	/ /19				
Home Address			City	State	ZIP
Home Phone	Work Phone		e-mail		
Emergency Contact	Phone		Physician		Phone

Please check the box that applies to you:

Race or Ethnic Background

- [ ] American Indian / Alaskan native
- [ ] Black, not of Hispanic origin
- [ ] White, not of Hispanic origin
- [ ] Asian
- [ ] Hispanic
- [ ] Other: ____________

2. ILLNESS & MEDICAL HISTORY

Identify all of the conditions or diseases for which you have been diagnosed and/or treated and indicate if the condition is current.

Cardiovascular Conditions	Check if Applicable	Current? (Yes / No)	Cardiovascular Conditions (cont.)	Check if Applicable	Current? (Yes / No)
Angina			Heart Problem (other)		
Anemia (low iron)			High Blood Pressure (controlled)		
Coronary Disease			High Blood Pressure (uncontrolled)		
Disease of the Arteries			Peripheral Vascular Disease		
Enlarged Heart			Phlebitis or Emboli		
Heart Attack			Pulmonary Emboli		
Heart Murmur			Rheumatic Heart Disease		
Heart Rhythm Problem			Other (Please List):		
Heart Valve Problem			Other (Please List):		

Metabolic, Renal & Hepatic Conditions	Check if Applicable	Current? (Yes / No)	Metabolic, Renal & Hepatic Conditions (cont.)	Check if Applicable	Current? (Yes / No)
Diabetes (Type1)			Renal / Kidney Problems		
Diabetes (Type 2)			Thyroid Problems		
Gout			Other (Please List):		

Pulmonary Conditions	Check if Applicable	Current? (Yes / No)	Pulmonary Conditions (cont.)	Check if Applicable	Current? (Yes / No)
Allergies			Chronic Restrictive Pulmonary Disease		
Asthma			Emphysema		
Bronchitis (chronic)			Orthopnea		
Chronic Obstructive Pulmonary Disease			Other (Please List):		

Inflammatory, Immune & Hematological Conditions	Check if Applicable	Current? (Yes / No)	Inflammatory, Immune & Hematological Conditions	Check if Applicable	Current? (Yes / No)
Aids / HIV			Lupus		
Anemia (Type):			Osteoarthritis		
Blood Clotting Disorders			Rheumatoid Arthritis		
Chronic Fatigue Syndrome			Other (Please List):		
Fibromyalgia			Other (Please List):		

Other Medical Conditions	Check if Applicable	Current? (Yes / No)	Other Medical Conditions (cont.)	Check if Applicable	Current? (Yes / No)
Cancer (Type):			High Anxiety / Phobias		
Depression			Hysterectomy		
Eating Disorders (anorexia, bulimia)			Menstruation Problems		
Epilepsy			Sleeping Problems		
Gallstones / Gallbladder Disease			Stomach / Duodenal Ulcer		
Hearing Loss			Substance Abuse Problems		
Other Health Problems					
Please list any other health problems and/or illnesses that may influence your physical activity.					

Orthopedic Problems / Conditions	Check if Applicable	Current? (Yes / No)	Orthopedic Problems / Conditions (cont.)	Check if Applicable	Current? (Yes / No)
Ankle or Foot Problems			Low Back Pain		
Elbow Pain			Osteoporosis		
Hip Problems			Shoulder Pain		
Knee Problems			Wrist or Hand Pain		
Orthopedic Problems					
Please describe the orthopedic issue identified above and/or list any orthopedic problem(s) that may influence your physical activity.					

3. SYMPTOMS or SIGNS SUGGESTIVE of DISEASE

Do you presently have or recently had (Check if Applicable):

Yes	Description	Yes	Description
	Have you experienced unusual pain or discomfort in your chest, neck, jaw, arms, or other areas that may be due to heart problems?		Do you suffer from swelling of the ankles (ankle edema)?
	Have you experienced unusual fatigue or shortness of breath at rest, during usual activities, or during mild-to-moderate exercise (e.g., climbing stairs, carrying groceries, brisk walking, cycling?		Have you ever experienced an unusual and rapid throbbing or fluttering of the heart?
	Have you had any problems with dizziness or fainting?		Have you ever experienced severe pain in your leg muscles during walking?
	When you stand up, or sometimes during the night while you are sleeping, do you have difficulty breathing?		Has your doctor told you that you have a heart murmur?
	Have you ever experienced a seizure?		Have you ever had unexpected weight loss of 10 lbs or more?

Have you ever had:	Check if Applicable	Date Diagnosed (M / Yr)
An abnormal chest x-ray?		
An abnormal electrocardiogram (ECG)?		
An exercise stress test?		
An abnormal exercise stress test?		

4. CHRONIC DISEASE RISK FACTORS

Do you presently have or recently had (Check if Applicable):

Yes	Description	Yes	Description
	Are you a male over 45 years of age? Are you a female over 55 years of age who has experienced premature menopause and is not on hormone replacement therapy?		Is your total serum cholesterol greater than 200 mg/dL, or has your doctor ever told you that your cholesterol is at high-risk level?
	Has your father or brother had a heart attack, heart operation, or died suddenly of heart disease before age 55; has your mother or sister experienced these heart problems before age 65?		Is your HDL cholesterol low (< 40 mg/dL for males, < 50 mg/dL for females), or has your doctor ever told you that your HDL cholesterol is at high-risk level?
	Has a doctor told you that you have high blood pressure (more than 140 / 90 mmHg), or are you on medication to control your blood pressure?		Are your triglyceride levels > 150 mg/dL, or has your doctor ever told you that your triglycerides are at high-risk level?
	Are you a current cigarette smoker or have you quit smoking within the last 6 months? Do you use smokeless tobacco?		Are you physically inactive and sedentary (little physical activity on the job or during leisure time)?
	Do you have diabetes mellitus?		Do you weigh more than 20 lbs more than you should?

5. ADDITIONAL FAMILY HISTORY

Check all of the conditions or diseases for which ***any member of your immediate family, including grandparents***, have been diagnosed and/or treated. Please provide their age and the date of occurrence or diagnosis if known.

Medical Condition	List Relative & Age at Diagnosis	Date Diagnosed (M / Yr)
High Blood Pressure before age 40		
High Cholesterol		
Obesity		
Diabetes		
Stroke under age 50		
Heart Attack under age 50		
Heart Operation		

6. PHYSICAL ACTIVITY

Please check the box that best describes you.

1. In general, compared to other persons your age, rate how physically fit you are:

Not at all fit	Slightly below average fitness	Average fitness	Slightly above average fitness	Extremely fit
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

2. Outside of your normal work, or daily responsibilities, how often do you engage in physical exercise?

☐ 5 or more times/week ☐ 3 - 4 times/week ☐ 1 - 2 times/week

☐ Less than 1 time/week ☐ Seldom or never

3. On average, how long do you exercise on each occasion?

☐ 10 - 20 min ☐ 20 - 30 min ☐ 30 - 40 min ☐ 40 - 50 min ☐ > 50 min

4. On a scale of 1 to 10 (1 being the lowest, 10 being the highest), how would you rate your exercise intensity ?

☐ Very Low (1 - 2) ☐ Low (3 - 4) ☐ Moderate (5 - 6) ☐ Mod-High (7 - 8) ☐ High (9 - 10)

5. How much strenuous physical work is required on your job?

☐ > 80% ☐ 60 – 80% ☐ 40 – 60% ☐ 20 – 40% ☐ None

7. MEDICATIONS

Please indicate any medications, prescription or "over the counter" by providing the name and dosage:

Medication Type	Name of Medication	Dosage
Heart Medicine		
Blood Pressure Medicine		
Blood Cholesterol Medicine		
Insulin		
Other Medicine for Diabetes		
Thyroid Medicine		
Medicine for Breathing / Lungs		
Medicine for Weight Loss / Weight Control		
Hormones		
Birth Control Pills		
Painkiller Medicine		
Arthritis Medicine		
Medicine for Depression		
Medicine for Anxiety		
Medicine for Ulcers		
Allergy Medicine		
Other (please specify):		

In addition to the above information that you have listed, are you aware of any other conditions, symptoms, or special circumstances that might be related to your overall health and well being? ________ If so, please explain. _____

____

Please list any specific goals or objectives you have for your exercise program.

____

____

____

____

APPENDIX C

- Hydration Habits Questionnaire

HYDRATION HABITS QUESTIONNAIRE

Subject #: _________

Circle the number that best describes how you feel

1. How important do you feel that drinking fluids is while you play sports or exercise? (circle one number)

   0 1 2 3 4 5 6 7 8 9 10

   |____|____|____|____|____|____|____|____|____|____|

   Not Important Very Important

   Why or why not?

2. Do you drink enough fluids while you play sports or exercise?

   0 1 2 3 4 5 6 7 8 9 10

   |____|____|____|____|____|____|____|____|____|____|

   never always

3. What kind of fluids do you drink during sports or exercise?

   Why do you choose these drinks?

4. Where do you get the fluids you drink during sports/exercise? (you may circle more than one)
   a. Team cooler b. Water fountain
   c. Water bottle from home d. Water bottle supplied by coach or team
   d. Other (please list)__________________

5. In a normal game or practice, how frequently do you drink? (you may circle more than one)
    a. Whenever I want (I will stop playing to go drink)
    b. Only during breaks
    c. When not playing
    d. When coach tells us
    e. I don't drink during practice/games
    f. Other (please explain)________________

6. Do you wish you could drink more fluids during practices and games?

0 1 2 3 4 5 6 7 8 9 10

|____|____|____|____|____|____|____|____|____|____|

Not at all A lot more

Explain why:

HYDRATION KNOWLEDGE QUESTIONNAIRE

Name: ___________________

1. Name two ways that you would know you are dehydrated

2. To be hydrated means to have a proper amount of fluids in your body (circle #)

0 1 2 3 4 5 6 7 8 9 10

|____|____|____|____|____|____|____|____|____|____|

strongly disagree strongly agree

3. When I am thirsty it means: (circle all that you think apply)
    a. I am almost dehydrated
    b. I am already dehydrated
    c. My core body temperature is high
    d. It is not related to my hydration status or body temperature

4. It is important to drink ______________________________.(circle one answer)
    a. Before and after exercise
    b. Before, during, and after exercise
    c. During and after exercise
    d. Before and during exercise

    Why did you choose this answer?

    Where did you learn this?

    Do you feel that you do this every time you exercise?

5. Name two reasons why someone's body temperature could rise to dangerous levels leading to heatstroke:

6. I do not need to drink fluids to perform at my best in my sport (circle #)

    0 1 2 3 4 5 6 7 8 9 10

    |____|____|____|____|____|____|____|____|____|____|

    strongly disagree strongly agree

7. What is sweat made of?

8. What color is your urine if you are hydrated? (circle one answer)
    a. Bright yellow (similar to "Mountain Dew")
    b. Pale yellow (similar to lemonade)
    c. Dark yellow (similar to apple juice)
    d. Brown Yellow (similar to mustard)

9. T F I sweat more if the practice is longer

10. T F I sweat more if it is hotter outside

11. How much on average should you drink during practice?
    a. The same amount that you sweat out
    b. Less than you sweat out
    c. More than you sweat out
    d. It doesn't matter

12. If I weigh less after a practice or game than I did at the beginning, then the weight I lost was probably due to ______________. (circle one answer)
    a. Fat loss
    b. Carbohydrate loss
    c. Sweat loss
    d. Protein Loss

13. T F Sweat loss is the same as fluid loss during exercise

14. On average, what amount do you think you sweat in a 2 hour practice? (answer in ounces using the bottle in front of you- example: 5 oz)

15. What is heat acclimatization?

16. How long does it take to completely heat acclimatize? (circle one answer)
    a. 1 day
    b. 4 days
    c. 12 days
    d. 20 days

17. T F Does heat acclimatization need to be completed before preseason practices start?

    Why?

18. Name two exertional heat illnesses

19. Name two ways you can prevent an exertional heat stroke in yourself or a friend

APPENDIX D

- Beverage Consumption Questionnaire (BEVQ-15)

PubMed Central, Figure 1: J Acad Nutr Diet. 2012 Jun; 112(6): 840–849. doi: 10.1016/j.jand.2012.01.023

Beverage Questionnaire (BEVQ-15)

Instructions:

In the past month, please indicate your response for each beverage type by marking an "X" in the bubble for "how often" and "how much each time".

Participant ID ____________________

Date ____________________

1. Indicate how often you drank the following beverages, for example, if you drank 5 glasses of water per week, mark 4-6 times per week.
2. Indicate the approximate amount of beverage you drank each time, for example, if you drank 1 cup of water each time, mark 1 cup under "how much each time".
3. Do not count beverages used in cooking or other preparations, such as milk in cereal.
4. Count milk added to tea and coffee in the *tea/coffee with cream beverage category* **NOT** in the milk categories.

	HOW OFTEN (MARK ONE)							HOW MUCH EACH TIME (MARK ONE)				
Type of Beverage	**Never or less than 1 time per week (go to next beverage)**	**1 time per week**	**2-3 times per week**	**4-6 times per week**	**1 time per day**	**2+ times per day**	**3+ times per day**	**Less than 6 fl oz (3/4 cup)**	**8 fl oz (1 cup)**	**12 fl oz (1 1/2 cups)**	**16 fl oz (2 cups)**	**More than 20 fl oz (2 1/2 cups)**
Water	O	O	O	O	O	O	O	O	O	O	O	O
100% Fruit Juice	O	O	O	O	O	O	O	O	O	O	O	O
Sweetened Juice Beverage/ Drink (fruit ades, lemonade, punch, Sunny Delight)	O	O	O	O	O	O	O	O	O	O	O	O
Whole Milk	O	O	O	O	O	O	O	O	O	O	O	O
Reduced Fat Milk (2%)	O	O	O	O	O	O	O	O	O	O	O	O
Low Fat/Fat Free Milk (Skim, 1%, Buttermilk, Soymilk)	O	O	O	O	O	O	O	O	O	O	O	O
Soft Drinks, Regular	O	O	O	O	O	O	O	O	O	O	O	O
Diet Soft Drinks/Artificially Sweetened Drinks (Crystal Light)	O	O	O	O	O	O	O	O	O	O	O	O
Sweetened Tea	O	O	O	O	O	O	O	O	O	O	O	O
Tea or Coffee, with cream and/or sugar (includes non-dairy creamer)	O	O	O	O	O	O	O	O	O	O	O	O
Tea or Coffee, black, with/ without artificial sweetener (no cream or sugar)	O	O	O	O	O	O	O	O	O	O	O	O
Beer, Ales, Wine Coolers, Non-alcoholic or Light Beer	O	O	O	O	O	O	O	O	O	O	O	O
Hard Liquor (shots, rum, tequila, etc.)	O	O	O	O	O	O	O	O	O	O	O	O
Wine (red or white)	O	O	O	O	O	O	O	O	O	O	O	O
Energy & Sports Drinks (Red Bull, Rockstar, Gatorade, Powerade, etc.)	O	O	O	O	O	O	O	O	O	O	O	O
Other (list):	O	O	O	O	O	O	O	O	O	O	O	O

The Brief 15-Item Beverage Intake Questionnaire (BEVQ-15)*†

*Scoring instructions are available from the corresponding author upon request.

†Sunny Delight, Sunny Delight Beverages Co., Cincinnati, Ohio; Crystal Light, Kraft Foods, Inc., Northfield, Illinois; Red Bull, Red Bull, Fuschl am See Austria; Rockstar, Rockstar Energy Drink, Las Vegas, Nevada; Gatorade, PepsiCo, Purchase, New York; Powerade, Coca-Cola Company, Atlanta, Georgia