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# The Effect of Half Time Sports Drink Ingestion on Subsequent Half Performance in U16 Female Soccer Players during Consecutive Matches

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THE EFFECT OF HALF TIME SPORTS DRINK INGESTION ON SUBSEQUENT HALF PERFORMANCE IN U16 FEMALE SOCCER PLAYERS DURING CONSECUTIVE MATCHES

by

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(Under the Direction of Amy Jo Riggs)

Abstract

The purpose of this study was to evaluate the effect of halftime sports drink ingestion on second half performance in U16 female soccer players using GPS technology. While 12 players initially took part in the study, only six players were included in the analysis (age, 15.97±0.45 years; height, 159.62±5.35cm; body mass, 54.87±4.25; body mass index, 21.58±2.10 kg·m$^{-2}$). In a double-blinded study design, twelve U16 female soccer players were randomly assigned to two groups (carbohydrate- sports drink or placebo). During half time of each game, players were provided with 500 ml of a drink and consumed the same liquid at halftime during all games of the first weekend, with the opposite beverage consumed during friendly matches on a subsequent weekend. Absolute running distance, distance covered per minute, distance covered in each of six velocity categories, and game load were tracked using GPS/HR during 2 games on 2 consecutive weekends. Distance covered at walking speed was significantly higher for the sports drink group ($F$ = 11.026; $p$= .007), specifically in the second half. Consequently, sports drink influenced distance covered at low-intensity running speed ($F$= 7.275; $p$= .021), while placebo group decreased distance covered in the second half comparing to first half, supplementation group increased from first to second half. There were no significant changes between groups for any other speed velocities variables. Despite the lack of significance found between groups, this study found a decrease in performance from first half to second half at fast running (F = 6.807;

$p = 0.024$), and high intensity running speed ($F = 19.648$; $p \leq .001$). No significant results were found at distance covered per minute. This study conclude that sports drink ingestion have no benefit in preventing deterioration in performance, and overall sports drink did not influence youth female soccer players performance throughout a weekend of games

*Key words:* Youth soccer, Female athlete, Global Positioning System (GPS), Sport drink, Carbohydrate drink, Running performance

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by

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS ....................................................................................................2

LIST OF TABLE ........................................................................................................5

CHAPTERS

1 INTRODUCTION ....................................................................................................6

Purpose Statement ..............................................................................................12

Hypotheses……………………………………………………………………………12

Limitations……………………………………………………………………………12

Delimitation…………………………………………………………………………...13

Assumptions………………………………………………………………...................13

Definitions…………………………………………………………………………......13

2 LITERATURE REVIEW……………………………………………………………....14

Soccer……………………………………………………………………………..…..14

Methods Utilized to Quantify Performance……………………………………….….16

Causes of Fatigue……………………………………………………………………..21

Carbohydrate Ingestion and Soccer Performance……………………………………26

3 METHODS & METHODOLOGY……………………………...……………………..31

Participants……………………………………………………………………………..31

Instrumentation……………………….........................................................................31

Exercise Protocol………………………………………………….....................32

Supplementation Protocol……………………………………………………...32

Anthropometric Measurements…………………………………………...…33

Time and Distance……………………………………………………………..33

Game Load…………………………………………………………….…….....................34

Food Record…………...……………………………………………………….34

Procedures……………….………………………..……………………….…..35

Study Time Line…………………………………………………………….....36

Statistical Analysis……………….………..……………………………..……...38

4 RESULTS..............................................................................................................39

Descriptive Analysis…………………………………………………………..39

Minutes Played…………………………………………………………………..39

Distance Covered…………………………………………………………...…40

Velocities………………………………………………………………………...40

Game Load……………………………………………………………………....43

Distance Covered per Minute…………………………………………...…..45

Game Results……………………………………………………………………47

5 DISCUSSION ..........................................................................................................48

REFERENCES…………………………………………………………………….....59

APPENDIX

A INFORMED CONSENT…………………………………………………………....64

LIST OF TABLES

Page

Table 1. Physical characteristics of the players participating in the study (n=6)………….39

Table 2. Absolute distance covered during first and second half………………………….44

Table 3. Table 3. Distance covered per minute during first and second half………………46

Table 4. Competition Schedule and Results……………………………………………..47

# CHAPTER 1

# INTRODUCTION

According to Federation Internationale de Football Association (FIFA) 265 million people are involved in soccer worldwide. This shows an increase of 10% since 2000, as well as a 50% increase in the number of women involved in soccer (FIFA, 2006). In the United States, over 3 million children were registered under US Youth Soccer, and nearly 50% of these numbers were female (US Youth Soccer, 2014). Soccer is associated with frequent intermittent high-intensity exercise while still being able to maintain possession of the ball, during which physiological demands (aerobic and anaerobic fitness) are necessary for a successful performance (Harley et al., 2010; Mohr, Krustrup, & Bangsbo 2003). The ability to accelerate and the distance covered are crucial for soccer performance (Arruda et al., 2015). Distances covered by a soccer player depend on several aspects such as age, fitness status, playing level, playing experience, and playing position. Youth soccer players cover an average of 5-10 km during a game (Harley et al., 2010). Despite a shorter game duration (40 minute halves), players under 16 years of age use the same size of field, size of ball, size of goal, and amount of players on the field as collegiate and professional soccer players.

Among youth team sports, male soccer players have received a lot of attention from coaches, exercise practitioners, and researchers (Atan, Foskett & Ali, 2014; Mendez-Villanueva, Buchheit, Simpson &Bourdon 2012). However, youth soccer players have not been studied equally when compared to adult soccer players. Despite a greater variation on maturation (i.e. the process of developing the body or mind) status, young players possess a lower aerobic and anaerobic capacity, limited glycogen storing capacity, and less developed thermoregulatory responses when compared to their adult counterparts (Atan, Foskett & Ali, 2014).

In recent years, a number of technological advances have provided the ability to quantify game-related soccer performance. Two of the most common methods are video analysis and Global Positioning Systems (GPS). Both of these methods enable running velocity to be captured throughout a game. Semi-automated video analysis systems use multiple cameras and angles that enable time-motion analysis of individual players. This technology has been used to track players and referee performances during a match (Bangsbo, Norregaard, & Thorsoe, 1991; Bradley et al., 2009; Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009; Mohr, Krustrup, &Bangsbo, 2003). However, one of the limitations of video analysis is the difficulty in determining the exact point that players cross movement-speed categories, which can be a concern in regards to inter- and intra-rater reliability of such systems and the mobility of camera setup when games are played away (Harley et al., 2010).

The application of global positioning system (GPS) satellite technology to the sporting environment provides the ability to collect and process data in real time. Consequently, GPS is fast becoming the primary tool to examine physical and physiological demands during match play (Atan, Foskett & Ali, 2014). In addition, GPS technology provides information that could not be previously obtained from video time-motion analysis such as acceleration, position, displacement, game load, and velocity (Arruda et al., 2015; Bradley et al., 2009; Buchheit et al., 2010; Harley et al., 2010; Wells et al., 2015). In addition to measurement of distances covered, GPS systems may also quantify measures of mechanical or physiological stress imposed during a given recording period. Technologies such as the Zephyr Bioharness (Model BH3, Zephyr Technology Corporation, Annapolis, MD, USA), can measures 5 physiological and activity variables (heart rate, breathing frequency, skin temperature, accelerometry, and posture) in real time. Game load is assessed via integration of heart rate (physiological) and accelerometry (mechanical) data. Quantification of stress accumulated over the course of a match can be calculated from internal and external work performed. All those values allow coaching staff to evaluate quantification of stress accumulated over the course of a match in real time (Johnstone et al, 2012).

When using GPS, performance is typically quantified as distance covered and/or time spent within pre-defined velocity zones of differing intensity. In order for comparisons across studies to be made, standardization of velocity thresholds is necessary. A recent study evaluated movement patterns of professional male soccer players across 5 competitive matches in an attempt to provide standardized velocity thresholds as a platform for the comparison of future studies (Dwyer and Gabbett, 2012). Velocity thresholds established in this study were as follows: standing (0-0.1 m/s), walking (0.2-2.0 m/s), jogging (2.1-3.7 m/s), running (3.8-6.0 m/s), and sprinting (6.1+ m/s). Another study with U12- U16 elite youth soccer players used the mean of five flying 10 meters sprints to assess their typical motion demands (Harley et al., 2010). This study found that match-play demands appear to be consistent across ages, however players become significantly faster in U14 and U15 age groups when compared to younger ages (Harley et al., 2010). Additionally, similar to Dwyer and Gabbett, 2012, U16 player's speed zone were divided into six categories: standing (0.46 $m \cdot s^{-1}$), walking (1.83 $m \cdot s^{-1}$), jogging (3.66 $m \cdot s^{-1}$), running (5.04 $m \cdot s^{-1}$), high-speed running (6.41 $m \cdot s^{-1}$), and sprinting (6.41 $m \cdot s^{-1}$). Post-game analysis enabled the quantification of distance covered in total (sum of zones 1–6), at high-intensity (zones 4, 5, and 6), at very high- intensity (zones 5 and 6), and at sprinting pace (zone 6) (Harley et al., 2010). However, gender differences in speed are found when comparing youth athletes. Vescovi and Favero, 2014, after analyzing physical performance characteristics of high-level female soccer players 12–21 years of age, used the following velocities in two different studies with female elite athlete: standing 0.0-0.1m/s (0.0-0.36 km/h), walking, 0.1-1.6m/s (0.37–6.0 km/h), jogging 1.69-3.3 (6.1–12.0 km/h); moderate running 3.36-4.3 (12.1–15.5 km/h); fast running 4.33-5.55 (15.6–20.0 km/h); and sprinting > 5.5 m/s (>20.0 km/h) (Dwyer & Gabbett, 2012; Vescovi & Favero, 2014). High intensity running (HIR) was account as ≥3.36 (≥15.5 km/h) and Low intensity running (LIR) ≤3.36 (≤15.5 km/h) (McCormack et al., 2015; Wells et al., 2015).

In contrast to professional and collegiate soccer players, youth soccer players frequently have successive matches with short break between games. Tournaments, showcases and friendlies typically involve a congested schedule of 1- 2 matches per day, or 3-6 matches within 3 days (Arruda et al., 2015). Studies have demonstrated that residual fatigue accumulated over successive matches could potentially decrease team-sport performance (Ronglan, Raastad, & Børgesen 2006; Spencer et al., 2005; Roswell et al., 2009). During each game, fatigue is more likely to appear during the second half (McCormack et al., 2014; Silva et al., 2013), potentially from depletion of skeletal muscle glycogen stores (Leatt & Jacobs, 1989), dehydration (Arnaoutis et al., 2013; Philips, Sykes, & Gibson, 2014), and/or contextual factors of the match (Arruda et al., 2015; Edwards et al, 2007; Lago et al, 2010; Mohr, Krustrup, &Bangsbo, 2003).

Prolonged intermittent-sprint exercise in hot and/or humid environments is also a concern due to the potential for dehydration (Godek et al., 2010). Reduction in exercise performance and detrimental consequences from dehydration can be experienced when these conditions are seen. Accordingly, recovery strategies are highly recommended to quickly regain performance, reduce risk of injuries, and alleviate post and during match fatigue (Nedelec et al., 2013). In youth soccer, players can perform multiple games in the same day or multiple games during the weekend. There is a concern about players starting the game already dehydrated from previous performances, and another concern is potentially letting players drink ad libitum during the game or during practice cannot prevent further dehydration in already dehydrated players (Arnaoutis et al., 2013). Edward et al., (2007) sought to determine whether moderate dehydration (~1.5-2% of body mass (BM)) would impair soccer performance, evaluated eleven moderately active male soccer players (24.4 ±3 years). In this experiment, players performed 45 minutes of cycle ergometry exercise before a match (90% of individual ventilatory threshold) before a 45 min soccer match; and they finished with an immediate post-match performance of sport-specific and mental concentration tests. Groups were divided in three different conditions frequently seen in studies of fluid intake and performance (fluid intake, no fluid, and mouth rinse). Post-match performance of sport specific fitness was significantly impaired when fluid intake was denied concluding that moderate dehydration is detrimental to soccer performance (Edwards et al., 2007). Consequently, it is important for youth athletes to consume fluids during prolonged exercises to avoid moderate dehydration for future performance during the weekend or the day. One study found that if sufficient carbohydrate-electrolyte solution is ingested before and at half-time, sprint performance and metabolism are not significantly affected when compared to consuming the same total volume ingested at the recommended 15-min intervals (Convertino et al., 1996). Another similar study found that there was no differences between thirst or gut fullness between trials (Clarke et al., 2005). The American College Sports Medicine recommendation are not realistic to the game, where there are no scheduled breaks during the match besides half-time break, which prevents players to have regular feeding of carbohydrate or drinking to prevent dehydration. Clark et al., (2005) sought that consuming a carbohydrate-electrolyte solution before a match and at half-time is a practical strategy for fluid provision during soccer at normal, ambient temperatures. Therefore, an optimal refueling and rehydration regime might be key in enhancing performance during a game (Clarke et al., 2005).

Commercially, there are overwhelming amounts of carbohydrate and electrolyte beverages specifically targeting athletes for prevent dehydration and potentially improve performance. Evidence has shown that ingesting a carbohydrate drink during a game could potentially attenuate decreases in performance, improve or maintain soccer skill performance, and attenuate decreases in muscle glycogen concentration from maintaining available or exogenous glucose sparing glycogen or endogenous stores, allowing players to perform better (Ali&Williams, 2009; Goedeck et al., 2013, Guerra, Chaves, Barros & Tirapegui, 2004; McGregor et al 1999; O'Reilly &Wong, 2013; Ostojic & Mazic, 2002; Russell, Benton, & Kingsley 2014). Decline in glycogen stores is associated with lower running speeds, and shorter distances covered during the second half when compared to the first half of a match (Saltin 1973). Glycogen may also be accompanied by reduced sprint performance (Krustrup et al. 2006).

Glucose ingestion before and during a soccer game has been shown to reduce net muscle glycogen utilization (Leatt & Jacobs, 1989). It has previously been observed that during periods of glycogen depletion, ingestion of a fluid containing carbohydrate can help maintain skill performance (Ali&Williams, 2009; Goedeck et al., 2013; Guerra, Chaves, Barros & Tirapegui, 2004; Leatt and Jacobs, 1898; McGregor et al., 1999; Nicholas, Nuttall, & Williams 2000; O'Reilly &Wong, 2013; Russell, Benton, & Kingsley 2014). Therefore athletes participating in multi day tournaments, showcases, or friendlies may benefit from carbohydrate interventions that enhance recovery during a match. Half time is considered important for matters relating to tactical strategy and recovery. Throughout the game, soccer players usually do not have the opportunity to ingest any fluid until the halftime break. Furthermore, there is currently a lack of consensus on whether soccer players should ingest carbohydrate beverages or water during soccer matches, making strategies of fluids replenishment a challenge for both coaches and players.

**Purpose Statement:**

In this research specific area, there is a lack of research examining the effect of half-time ingestion of a sports drink in female youth soccer players. Therefore, the purpose of this study was to evaluate the effect of sports drink ingestion during halftime on second half performance in U16 female soccer players.

**Hypothesis**

1. It was expected that sports drinks will attenuate declines in performance in the second half, having supplementation group with higher distance covered at high-intensity running speed when comparing to placebo group

**Limitations**

- Small subject group: study will recruit a limited amount of players (<15 players)
- Could not control diet 100% throughout the study
- Study did not have a training intervention
- Could not control training or playing volume for all subject
- Could not control injuries

- GPS/HR underestimate distance covered
- Only data from players who played more than 75% of the game (i.e. 60 minutes, 30 minutes per half) was utilized.
- 10hz GPS bio harness system only calculates on 1 hz

**Delimitations**

- Athletes 14 to 16 years old
- Subjects were recruited from one soccer club
- Because this study worked with a minor population, the study was not able to control menstrual cycle or control the ingestion of birth control.

**Assumptions**

- Study assumed that participants followed protocol of avoiding excess carbohydrate during the weekends that data was collected.
- Participants avoided any extra activity on testing weekend.

**Definition**

- Carbohydrate ingestion: Gatorade
- Placebo: MIO liquid water enhancer
- Friendlies: soccer games that are not playing during a tournament

# CHAPTER 2

# LITERATURE REVIEW

## Soccer

According to Federation Internationale de Football Association (FIFA) 265 million people are involved on soccer worldwide. This shows an increase of 10% since 2000, and 50% increase in the number of women involve in the soccer game (FIFA, 2006). In the United States, over 3 million children were registered under US Youth Soccer, where nearly 50% of these number were girls (US Youth Soccer, 2014). Youth soccer players under 16 years old play on a field measuring between 50-100 yards in width and 100-130 yards in length, using size ball 5, 11v11 match format (10 field players and 1 goalkeeper), and two half of 40 minutes with 10-15 minute break between halves (US Youth Soccer, 2012). Substitutions are unlimited unless it is specified otherwise in the rules and changes regulations often seen in a special competition. If there is a change in the rule regulation, this will reflect a similar setting to collegiate athletes where players cannot re-enter the game in the first half after being substitute, but would allow one re-entry in the second half if they are substitute (NCAA-Book Rule, 2015).

Distances covered by a soccer player depend on several aspects as age, fitness status, playing level and experience, and playing position. Youth soccer player cover in average 5-10 km during the game (Arruda et al., 2015; Buchheit et al., 2010; Harley et al., 2010). Soccer game is associated with frequent intermittent high- intensity exercise still being able to maintain possession of the ball, where physiological demands (aerobic and anaerobic fitness) are necessary for successful performance (Harley et al., 2010; Mohr, Krustrup, & Bangsbo 2003). Soccer is complex sport that involves tackles, jump, and direction and speed changes (Bangsbo 1994). Activity and movement profiles vary widely between individual players across consecutive matches, although a pattern characterized by long bouts of low to moderate intensity activity (e.g. standing, walking, jogging) interspersed with brief bouts of high intensity activity (e.g. sprinting, jumping, tackling, fighting for possession of the ball, etc) are frequently observed. In elite level players, the combination of high intensity running and sprinting is reported to account for approximately 10% of the total distance covered during a competitive match (Mohr, Krustrup, & Bangsbo 2003). Additionally, sprinting and speed is highly age and position dependent in youth soccer players (Buchheit et la., 2010; Haddad at al., 2015).

Different from professional and collegiate soccer players, youth soccer players often have successive matches with a short period of rest between matches. Tournaments can involve 1 or 2 matches per day or 3-6 matches within a 3 day period (Arruda et al., 2015). Studies have demonstrated that residual fatigue accumulated over successive matches can potentially decrease team-sport performance (McCormack, et al,, 2014; Ronglan, Raastad, & Børgesen 2006; Spencer et al., 2005, Rowsell, Coutts, Reaburn, &Hill-Hass, 2009; Well et al., 2015). Research suggests that peak muscle soreness occurs at 27 hours post-match, and it does not return to baseline until 69 hours after the match (Andersson et al., 2008). During the game, fatigue is more likely to appear in the second half of the game (McCormack et al., 2014; Silva et all., 2013; Wells et al., 2015), potentially from depletion of skeletal muscle glycogen stores (Leatt & Jacobs, 1989; ; Nielsen et al, 2012), dehydration (Arnaoutis et al., 2013; Philips, Sykes, & Gibson, 2014) and contextual factors of the match (Arruda et al., 2015; Edwards et al, 2007; Lago et al, 2010).

In 2014, McCormack et al., recruited 10 female Division I college soccer players (20.5±1.0yr; 166.6±5.1cm; 61.1±5.8kg) to determine performance differences between Friday and Sunday (<48 hours rest) matches during (<48 hours rest) during 2014 soccer season. 10-Hz

GPS device across were assessed during eight weekends with matches played on Friday evenings and Sunday afternoons. There was no differences in minutes played, distance rate, or number of sprints between Friday and Sunday matches. However, there was a significant decrease ($p=0.017$) in rate of high intensity run (HIR) between Friday ($25.37\pm7.22$ m·min) and Sunday matches ($22.90\pm5.70$ m·min). In addition, there was a trend toward a difference ($p=0.073$) in the number of efforts of HIR between Friday ($138.41\pm36.43$) and Sunday ($126.92\pm31.31$). Another study used GPS similarly to qualify performance recruited ten U15 soccer players (Arruda et al., 2015). This study reported that congested match schedule influenced body-load impact and acceleration, potentially decreasing performance after analyzing 5 matches performed over 3 successive days (Arruda et al., 2015).

Based on those previously conducted studies, a congested schedule could affect performance during the weekend, especially during the most important games of the weekend (semifinal and final). It could also suggest that a congested schedule throughout the month could impact performance if correct recovery is not followed by the athlete. Athletes involved in multi day tournaments, showcase, or friendlies could benefit from certain interventions that maximize recovery prior the next match or training.

**Methods Utilized to Quantify Performance**

Soccer performance has been examined through different methods. Previously, heart rate measures were used to quantify physiological stress during soccer activity. Buchheit et al.,(2012) recruited a group of 46 young soccer players (age $15.1 \pm 1.5$ years) to verify the validity of using exercise heart rate, heart rate recovery and post-exercise heart variability during and after submaximal two consecutive (3-4 months apart) testing sessions during an entire competitive season. In this study, results showed that a substantial improvement in heart rate recovery was not associated with beneficial changes in any cardiorespiratory fitness-related performance. However, there is a lack of studies using heart rate responses over the course of match and season.

In recent years, semi-automated video analysis system has been used to track players and referee performance during the games (Bangsbo, Norregaard, & Thorsoe, 1991; Bradley et al., 2009; Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009; 3r, Krustrup, &Bangsbo, 2003). This system uses multiple cameras and angles, which they are looking for players time-motion. One study assessing physical fitness, match performance, and development of fatigue during competitive matches used computerized time-motion analyses performed 2-7 times during the competitive season in two high standards of professional soccer (Mohr, Krustrup, &Bangsbo, 2003). Players were video-filmed during the match using a VSH-format camera (positioned in different position along the field). Videotapes were reviewed after the game where computerized code activity patterns on locomotor speed categories [standing (0 km×h), walking (6 km×h), jogging (8 km×h), low-speed running (12 km×h), moderate-speed running (15 km × h ), high-speed running (18 km×h), sprinting (30 km×h) and backward running (10 km × h )]. Eighteen top-class (age 26.4 + 0.9 years, body mass 75.4 + 1.5 kg, height 1.80 + 0.01 m), and twenty-four moderate professional soccer player (26.5 + 1.0 years, body mass 75.4 + 1.7 kg, height 1.81 + 0.02 m) were analyzed during competitive matches. Despite the expected superior performance ability from top-class player, this study found that fatigue occurred towards the end of matches as well as temporarily during the game, independently of competitive standard and of team position where the amount of high-intensity running (independent of competitive standard and playing position) was lower (35–45%; $P<0.05$) in the last 15 minutes rather than in the first 15 min of the game (Mohr, Krustrup, &Bangsbo, 2003).

One of the limitations of video analysis is the difficulty to determinate the exact point that players crosses movement speed categories, which can be a concern regards of inter- and intra-rater reliability of such systems (Harley et al., 2010). Recently, another method of quantify soccer performance has been studied and shown to minimize those limitations found on video time-motion analysis. The application of global positioning system (GPS) satellite technology to sports environment brought the ability to collect and process data quickly, and it has become the primary tool to examine physical and physiological demands during match play (Atan, Foskett & Ali, 2014). Randers et al., 2010, compared activity pattern and fatigue development in the same soccer match using video-based time–motion analysis system, a semi-automatic multiple-camera system, and two commercially available GPS systems (GPS-1; 5 Hz and GPS-2; 1 Hz). In this study, video-based observational coding showed to underestimate total distance covered and high-intensity running when compared with a differential global positioning system ($P < 0.001$; Randers et al., 2010). In addition, GPS technology provides information that could not be previously obtained from video time-motion analysis as acceleration of field sport athletes, quantitative information on the position, displacement, and velocity (Arruda et al., 2015; Bradley et al., 2009; Buchheit et al., 2010; Harley et al., 2010; Wells et al., 2015).

When using GPS, performance is expressed in distance covered at different movement intensities. A standardized velocity threshold is necessary to allow comparison between studies. One study evaluated movement patterns of professional male soccer players during 5 competitive matches seeking to determine a standard velocity threshold for future studies (Dwyer and Gabbett, 2012). The velocity threshold established in this study was as follows: standing (0-0.1 m/s), walking (0.2-2.0 m/s), jogging (2.1-3.7 m/s), running (3.8-6.0 m/s) and sprinting (6.1+

m/s). A similar study was conducted with elite youth soccer players and used the mean of 10 m sprint to assess the motion demands of elite youth soccer players in the U12 to U16 age-groups (Harley et al., 2010). This study found that match-play demands appears to be consistent across the ages, however players become significantly faster in U14 and U15 age groups when compared to younger ages (Harley et al., 2010). Additionally, similar to Dwyer and Gabbett, 2012, U16 player's speed zone were divided: standing (0.46 m•s$^{-1}$), walking (1.83 m•s$^{-1}$), jogging (3.66 m•s$^{-1}$), running (5.04 m•s$^{-1}$), high-speed running (6.41 m•s$^{-1}$), and sprinting (6.41 m•s$^{-1}$ ). Post-game analysis enabled the quantification of total distance covered (sum of zones 1–6), and distance covered at high-intensity (zones 4, 5, and 6), very high- intensity (zones 5 and 6), and at sprinting pace (zone 6) (Harley et al., 2010).

Additionally, GPS has been used to analyze playing positions in youth soccer players (Buchheit et al., 2010). Seventy-seven youth soccer players (U13-18 age group) were examined during 42 international club games. Match running performance and physical capacity were position-dependent. Center backs presented the lowest total distance when compared to all positions ($p<0.05$), and wide midfielder and strikers showed the highest very-intensity activity values ($p<0.05$) (Buchheit et al., 2010).

The ability to accelerate is considered decisive in critical activities performed during soccer matches. Numbers of hard acceleration and decelerations segments are related to fatigue and recovery in elite soccer player (Nedelec et al., 2013). The ability to maintain elevated number accelerations during the game, or consecutive games, within short time period is crucial in player's performance (Arruda et al., 2015). One study analyzing a congested match schedule examined total distance (TD) covered, high-intensity-running (HIR) distance, and frequency of acceleration and body-load impacts (BLIs) in ten U-15 soccer players (15.1±102 y, 1.71±0.48 m, 61±6.0 kg) during 5 international matches performed over 3 successive days (Arruda et al., 2015). Body-load impact was determined using the summed accelerations from 3 accelerometer planes. The load and intensity measures for these impacts can be identified as the total number of impacts and impacts per minute, respectively. This study used global positioning system (GPS) on 5 matches lasting 50-60 minutes (2 halves of 25 or 30 minutes and 10 or 15 minutes of halftime interval). No differences was presented for TD covered, TD run per minutes, number of high-intensity runs, distance covered in HIR, per-minutes peak running speed attained, or frequency of acceleration. However, there were significant differences between matches for the frequency of acceleration per minutes, BLIs, and BLIs per minute ($p<0.05$), showing that body-load impact and acceleration were most influenced by the congested schedule (Arruda et al., 2015).

Technology has allowed players to wear products with more accessible ways. A newer product such as Bioharness 3™ allows an integrated approach to in-game analysis and is a wearable harness that provides both physiological data (e.g. heart rate, breathing rate, skin temperature) and spatial data obtained from GPS units in the one harness. The GPS unit transmits data via Bluetooth to a module located on participant’s left side placed along the midaxillary line, even with the xyphoid process of the sternum. This harness has electrode sensors installed within a chest strap. Bioharness 3™ is able to detect heart rate at sampling rate of 250 Hz, and a GPS unit (Qstarz 818XT, Taipei, Taiwan) housed on the upper thoracic spine sampling at 1Hz, allows for the assessment of the game load via integrated assessment of heart rate and accelerometry data. Quantification of stress accumulated over the course of a match can be calculated from internal and external work performed. Game load combines physiological and mechanical load values, allowing coaching staff to evaluate quantification of stress accumulated over the course of a match in real time (Johnstone et al, 2012).

Despite the lack of research available using the Bioharness 3™ harness to quantify game load over the course of a competitive, the use of the Bioharness™ is considered valid and reliable for measures of distance and heart rate during soccer specific activities after been shown to have high levels of for measures of heart rate during an incremental treadmill running protocol (Johnstone et al, 2012). Additionally, 1 Hz GPS has previously shown to be both valid and reliable for quantifying distance covered during soccer specific activities (**Portas et al, 2010**).

**Causes of Fatigue**

Studies have demonstrated that residual fatigue accumulated over successive matches can potentially decrease team-sport performance (McCormack, et al,, 2014; Ronglan, Raastad, & Børgesen 2006; Spencer et al., 2005, Rowsell, Coutts, Reaburn, &Hill-Hass, 2009; Wells et al., 2015). Low substrate availability is also a potential cause of fatigue in soccer (OReilly et al., 2008). During the game, fatigue is more likely to appear in the second half of the game (McCormack et al., 2014; Silva et al., 2013), potentially from depletion of skeletal muscle glycogen stores (Leatt & Jacobs, 1989; Nielsen et al, 2012), dehydration (Arnaoutis et al., 2013; Edwards et al., 2007; Philips, Sykes, & Gibson, 2014), and contextual factors of the match (Arruda et al., 2015; Edwards et al, 2007; Lago et al, 2010; Mohr, Krustrup, &Bangsbo, 2003). The decline in glycogen stores is reflected by lower running speeds and shorter distances covered during the second half compared to the first half of a match (Saltin 1973), as well as reduced sprint performance (Krustrup et al. 2006). Recovery strategies are highly required in order to alleviate post and during match fatigue ass to regain performance faster and reduce risk of injuries (Nedelec at al., 2013).

As mentioned before, dehydration can play role in appearance of fatigue during a soccer match. Prolonged intermittent-sprint exercise in hot and/or humid environments is common, especially during pre- season training of soccer (Godek et al., 2010). Reduction in exercise performance and detrimental consequences from dehydration can be experienced when these conditions are met. One study investigated the hydration status and fluid balance of fourteen (age 16.9 ± 0.8 years, height 1.79 ± 0.06 m, body mass (BM) 70.6 ± 5.0 kg) elite European youth male soccer players during three consecutive training sessions. Hydration status was assessed through urine specific gravity (USG) from the first morning urine (baseline) and pre-and post-training urine samples. Fluid balance was calculated from pre to post- training body mass change after corrected for fluid intake and urine output. Results showed that most participants were hypohydrated upon at baseline (USG >1.020; 77% on days 1 and 3, and 62% on day 2, and no significant difference occurred between first morning and pre-training USG ($p = 0.11$). Additionally, there was no influence of training session ($p = 0.34$) or time (pre- vs. post-training; $p = 0.16$) on USG, concluding that consumption of fluid *ad libitum* throughout training appears to prevent excessive (≥2% BM) dehydration (Philips, Sykes, & Gibson, 2014). In contrast with Philips, Sykes, & Gibson, 2014, another study evaluated 107 young male soccer players (age 11-16) pre-exercise hydration status and post-exercise body-water balance during a summer sports camp (Arnaoutis et al., 2013). Hydration status was assessed via urine specific gravity (USG), urine color, and changes in total body weight. From 107 players, 95 were hypohydrated before practice according to USG>1.020, and dehydration was observed on both days (95.8% and 97.2%) after training, concluding that drinking ad libitum during practice did not prevent further dehydration in already dehydrated players (Arnaoutis et al., 2013).

Another study sought to determine whether moderate dehydration (~1.5-2% of body mass (BM)) would impair soccer performance. Eleven moderately active male soccer players

(24.4 ±3 years, BM 74.03 ±10.5 kg) were recruited to participate in experimental procedure that consisted of 45 minutes of cycle ergometry exercise before a match (90% of individual ventilatory threshold) followed by the completion of a 45 min soccer match; and finishing with a immediate post-match performance of sport-specific and mental concentration tests. These procedures were completed in three different conditions: 1. fluid intake (FL), 2. no fluid (NF) and mouth rinse (MR). Core temperature (Tc), heart rates, plasma and urine osmolalities, BM, sweat rate and heat storage were measured. Post-match performance of sport specific fitness was significantly impaired when fluid intake was denied ($p<0.01$), concluding that moderate dehydration is detrimental to soccer performance (Edwards et al., 2007).

Leatt & Jacobs, 1989, recruited ten-male soccer players to examine the effect of muscle glycogen utilization of drinking a glucose polymer solution before and during a soccer match. Experimental team (n=5) ingested 0.5 L of 7% glucose polymer 10 minutes before the game and at halftime, and the control team ingested the same amount of placebo at the same time. Muscle biopsy was assessed before and after the game. Changes in the levels of muscle glycogen were less ($p<0.01$) evident in the experimental team (111±24 mmol glucose unit•$kg^{-1}$ dry muscle) than in control team (181±24 mmol•$kg^{-1}$). Despite the lack of changes in blood glucose throughout the game in either group, this study concluded that glucose ingestion before and during soccer game reduces net muscle glycogen utilization (Leatt & Jacobs, 1989).

One study assessing physical fitness, match performance, and development of fatigue used 18 top-class players and 24 moderate professional soccer players during competitive matches. This study used computerized time-motion analyses performed 2-7 times during the season. Despite the expected superior performance ability from top-class player, this study found that fatigue occurred towards the end of matches as well as temporarily during the game, independently of competitive standard and of team position where the amount of high-intensity running (independent of competitive standard and playing position) was lower (35–45%; $P<0.05$) in the last than in the first 15 min of the game (Mohr, Krustrup, &Bangsbo, 2003).

Among youth team sports, male soccer players have received a lot attention by coaches, exercise practitioners, and researchers (Atan, Foskett & Ali, 2014). However, match analysis in youth soccer players have not been studied whereas adult match play has. Despite of greater variation on maturation status, young players possess lower aerobic and anaerobic capacity, limited glycogen stores, and less developed thermoregulatory responses (Atan, Foskett & Ali, 2014).

In one study involving youth soccer players, twenty high-performance junior male soccer players (15.9±0.6 y) investigated the effect of water immersion on physical test and perception of fatigue and recovery during 4-day simulated soccer tournament. Participants played four matches (90 minutes game) in four days. Twenty minutes after each game, cold-water immersion (cold bath) and thermoneutral immersion condition (thermoneutral bath) were executed. In addition to the water immersion, players performed an exercise protocol consisted of counter movement jump, 12x20 meter repeated sprint (20 seconds rest between sprint), and 5 minutes steady-state submaximal running at approximately 12 kmh. Additionally, heart rate, intracellular proteins, and inflammatory markers were recorded approximately 90 min before each match and 22 h after the final match. No significant reductions were found in countermovement jump height and repeated sprint ability ($p= 0.74$ and $p=041$ respectively). Despite the ability of immediate post-match water immersion on reducing the perception of general fatigue and leg soreness between matches in tournaments, both groups experienced increases on post-shuttle run ($p=0.48$), muscle damage and inflammation markers [creatine kinase ($p=0.004$), lactate dehydrogenase ($p< 0.001$)]

concentrations. This study demonstrated that markers of muscle damage could accumulate when matches are played on successive days and effective recovery is crucial in these situations (Rowsell, Coutts, Reaburn, &Hill-Hass, 2009).

Another study analyzing congested match schedule examined total distance (TD) covered, high-intensity-running (HIR) distance, and frequency of acceleration and body-load impacts (BLIs) in ten under-15 soccer players (15.1±102 y, 1.71±0.48 m, 61±6.0 kg) during 5 international matches performed over 3 successive days. This study used global positioning system (GPS) on 5 match lasts 50-60 minutes (2 halves of 25 or 30 minutes and 10 or 15 minutes of halftime interval). No differences was presented for TD covered, TD run per minutes, number of high-intensity runs, distance covered in HIR, per-minutes peak running speed attained, or frequency of acceleration. However, there were significant differences between matches for the frequency of acceleration per minutes, BLIs, and BLIs per minute ($p<0.05$), showing that body-load impact and acceleration were most influenced by the congested schedule (Arruda et al., 2015).

Similar finds were observed on McCormack et al., study when analyzing 10 female Division I college soccer players (20.5±1.0yr; 166.6±5.1cm; 61.1±5.8kg) playing on Friday and Sunday (<48 hours rest) during 2014 soccer season. 10-Hz GPS device assessed the players during eight weekends with matches played on Friday evenings and Sunday afternoons. There were no differences in minutes played, distance rate, or number of sprints between Friday and Sunday matches. However, there was a significant decrease ($p=0.017$) in rate of HIR between Friday (25.37±7.22 $m \cdot min^{-1}$) and Sunday matches (22.90±5.70 m·min-1). In addition, there was a trend toward a difference ($p=0.073$) in the number of efforts of HIR between Friday (138.41±36.43) and Sunday (126.92±31.31), concluding that NCAA division I female soccer players cover less distance of high intensity run in the games played less than 48 hours after the first game (McCormack et al 2015).

**Carbohydrate Ingestion and Soccer Performance**

During a soccer match, half time is considered a tactical and recovery important part of the game. Throughout the game, soccer players usually do not have the opportunity to ingest any fluid until half time. There are no specific recommendation rather soccer players should ingestion carbohydrate beverage or water during soccer matches.

Commercially, there are several carbohydrate beverages targeting athletes. At elite level, the biggest reason for a decrease in performance is from fatigue. This fatigue is often associated with muscle depletion or decrease of glycogen (Bangsbo, 1992). It is believed that ingesting a carbohydrate drink during a game simulation situation, or during actual game could potentially increase distance covered and number of sprints, improve or maintain soccer skill performance, and increase muscle glycogen concentration from maintaining available or exogenous glucose sparing glycogen or endogenous stores, allowing players to perform better (Ali&Williams, 2009; Goedeck et al., 2013, Guerra, Chaves, Barros & Tirapegui, 2004; McGregor et al 1999; O'Reilly &Wong, 2013; Ostojic & Mazic, 2002; Russell, Benton, & Kingsley 2014).

One study examined the effects carbohydrate and carbohydrate-free ingestion has on 60 minutes soccer-specific training on skill, performance, hydration, and core temperature (Tc) (O'Reilly &Wong, 2013). Seven healthy male soccer players (23±2.9 year, height 1.7 ±0.04 m, body mass 62.7±6.7 kg) were randomized in a crossover study design with groups ingesting 2 mL of fluid per/kg body mass of 6.6% CHO-electrolyte drink or the same amount on placebo every 15 minutes during exercise. Prior to and after 60 minutes of training in a hot and humid environment (30 ◦C, 85% relative humidity) participants performed skill tests [Loughborough

Soccer Passing Test (LSPT)]. Their blood glucose, blood lactate, and Tc were monitored throughout the exercise session as well. Despite the lack of significant differences on core temperature and body mass ($p>0.05$), consuming CHO drinks had a significant improvement in movement time ($p=0.034$) and overall LSPT performance ($p=0.031$) concluding that ingestion of carbohydrate during exercise could improve postexercise skill performance (O'Reilly &Wong, 2013).

Using the same Loughborough Soccer Passing Test (LSPT), in 2009, Ali & Williams, investigated the effect of ingesting a 6.4% carbohydrate-electrolyte solution during the 90 minutes of Loughborough Intermittent Shuttle Test (LIST), on soccer skill performance test (using LSPT). Seventeen male soccer players were recruited (20.9 ± 2.5 y; height 1.74 ±0.05 m; body mass 71.5±5.4 kg; $VO_{2max}$ 59.0±3.1 ml•kg$^{-1}$ •min$^{-1}$), and were divided in two groups. Each group ingested CHO, or placebo solution equivalent to 8 ml •kg$^{-1}$ body mass before and 3 ml•kg$^{-1}$ body mass after every 15 minutes of exercise. The study was a double-blind randomized cross-over design with trials separated by 7 days. Different from O'Reilly &Wong study, players were asked to perform a glycogen-reducing exercise on a cycle ergometer (80 moin at 70% $VO_{2max}$) in the evening before the main trial. After the exercise, players were fed with a low-carbohydrate meal. After 12-h overnight fast, the participants completed six 15-min blocks of the Loughborough Intermittent Shuttle Test interrupt by 4-min rest periods. Each block consisted of approximately 11 repeated cycles of walking, running (at a speed equivalent to 95% $VO_{2max}$), jogging (at a speed equivalent to 55% $VO_{2max}$), and sprinting. During the 4 minutes rest periods, the participants ingested the beverage specific to the group and then players performed the Loughborough Soccer Passing Test. The LSPT requires participants to complete 16 passes against coloured targets, whilst manoeuvring around a grid of cones and lines. Performance comprises time to complete the passes plus any additional penalty time for inaccurate passing or poor control of the ball. Additionally, participants were asked to record their food and drink consumption for the 2 days prior to the first of the main trials and to replicate their intake before the second main trial. A significant difference on time was observed (p=0.001) with differences between 0-45 and 75-90 minutes ($p < 0.05$). Both groups showed a reduction of skill performance before, during, and after the exercise, however in the CHO group reduction was 3% and placebo trial performance decreased 14 % (p=0.07). Despite of a decrease in performance in the last 15-30 min of exercise, this study concluded that providing $52g \cdot h^{-1}$ carbohydrate drinks during the exercise could better maintain soccer skill performance when compared to placebo group (Ali&Williams, 2009).

Another cross-over study performed by soccer players, investigated how 700 ml of 7% carbohydrate solution could affect performance in postprandial soccer players when compared to a placebo during a simulated soccer match (Goedeck et al., 2013). Twenty trained male soccer players (24±7 y, 73.4±12.0 kg) completed two trial separated by 7 days. Similar to Ali & Williams, this study also used 90 minutes of Loughborough Intermittent Shuttle Test (LIST) as a soccer simulation game, then Ratings of perceived exertion (RPE), agility, timed run to fatigue (20 m runs at progressively increasing speeds) were measured during the trials. Before the LIST starts, boy mass was assessed and participants performed an agility test. After every 15 minutes block of LIST, rating of perceived exertion (RPE) was measured and players ingested 50 ml specific drink for their groups on that trial. Agility test was performed again after 75 min of LIST (5 block of 15 minutes), and run to fatigue test (20 m runs at progressively increasing speeds) was performed after agility, by completing 90 minutes of exercise. RPE and body weight was assessed after the end of exercise test. Agility time and RPE did not alter between groups (p=.0.81 and p=0.87 respectively), and time run to fatigue were 381 ± 267 s vs. 294 ± 159 s for the CHO and placebo drinks, respectively ($p = 0.11$). However, body mass modified the relationship between time to fatigue and drink ingestion ($p = 0.02$ for drink × body mass), such that lower body mass became associated with increased time to fatigue when the players ingested CHO, but not placebo, concluding that when adjusting for body mass, increasing CHO intake was associated with an improved time to fatigue during the simulated soccer match (Goedeck et al., 2013).

When analyzing youth soccer players, Russel, Benton, & Kingsley, 2014, looked at carbohydrate ingestion before and during soccer match, investigating exercise-induced rebound glycemic response through blood glucose and lactate concentration. This study used ten male outfield academy soccer players (age =15.6±0.2 years) in a crossover study. Participants ingested 6% CHO-electrolyte solution or a placebo solution (containing electrolyte) 2 hours before kickoff, before each half (within 10 min), and every 15 minutes throughout the game. The blood samples were collected at baseline, 10 minutes into half-time break, and every 15 minutes during the match. There was a positive influence from the CHO ingestion on blood glucose during the game. Concentrations were higher at 30 to 45 minutes in the CHO group (time x treatment interaction effect, $p \leq .05$), however during the second half there is no difference in blood glucose concentration between groups, and blood lactate concentrations were elevated above those at rest in the first 15 minutes of exercise (time-of-sample effect; $P < .001$) and remained elevated throughout exercise. Ingestion of a 6% CHO-electrolyte beverage before and during a soccer match did not show potential benefits during second half of the soccer game, indicating that supplementation did not influence the pattern of response (time x treatment interaction effect p= 0.49) (Russell, Benton, & Kingsley, 2014).

In another study using youth soccer players, research investigated the influence of fluid ingestion on performance of soccer players during a match (Guerra, Chaves, Barros & Tirapegui, 2004). Twenty male youth soccer players (age=16.01±1.11y) participated in the CHO beverage intervention during a 75 minute game (45 minutes half, 15 minutes of interval followed by 30 minutes half). Players were divided in two groups (CHO or water-NCHO). CHO groups (n=10) ingested Gatorade (6% CHO solution) every 15 minutes during the game; both groups were allowed to ingest water ad libitum during halftime. Heart rate (Polar Sport Tester S610, Finland) and core temperature (Cor Temperature Disposal Temperature Senson and Cor Temp 2000) were assessed every 15 minutes during the match. Performance was measured during the game from observation of twenty volunteers, and core temperature was assessed every 15 minutes as well. During the second half, HR of NCHO (n=10) group was higher compared to CHO groups ($p<0.05$). Additionally, during the first half CHO group performed more sprints than NCHO group ($p<0.05$), concluding that carbohydrate beverage indicates to be beneficial on preventing deterioration in performance (Guerra, Chaves, Barros & Tirapegui, 2004).

Although the US Soccer Federation allows teams to complement an additional water break before half time when temperature and humidity are high, generally there are no water breaks or clear opportunities for all players in the game to ingest any fluid until substitution or half-time. This goes against ACSM recommendations of ingestion of fluids every 15 minutes during high intensity activity (ACSM, 1996). Therefore, none of these studies are realistic to the game scenario ingesting fluids every 15 minutes where players could potentially ingest a beverage before and during half time during a true match.

# CHAPTER 3

# MATERIAL AND METHODOLOGY

## Participants

Twelve youth female soccer players from the same team volunteered to participate of this study. Players ranged from regional to national competitive level, training at least five days per week or six hours per week over the five day period. Inclusion criterion required players to be involved in the game for at least 30 minutes per half, during both halves in all four games. Twelve players took part in the study (age 16.37±0.41 years; height 163.10±5.83cm; body mass, 56.48±5.12 kg; body mass index, 21.28±2.16 kg·$m^{-2}$). The team assessed was involved in the end of spring season and all four games were part of friendlies playing against U15-U17 youth female teams with range of state, region, and competitive level. All participants were fully informed about the nature and demands of the study. Written minor assent and parental consent were obtained from all participants and their respective parents or guardians. Any individual that had Diabetes or allergies from any type of Gatorade ingredients or MIO water enhancer was not be able to participate in the study. Additionally, all participants were asked to complete a health history questionnaire. Participants were informed that they could withdraw from the study at any time, with no penalty or negative consequence, even after giving written consent. This study was approved by the Institutional Review Board (IRB) at Georgia Southern University as well as written permission from the director of the soccer club.

**Instrumentation**

**Exercise protocol.** Twelve U16 female soccer players were randomized and outfitted for the Zephyr bioharness (Model BH3, Zephyr Technology Corporation, Annapolis, MD, USA), and a 10 Hz global positioning receiver/transmitter (BT-Q818XT, QStarz, Taipei, Taiwan) 15 minutes before the beginning of the warm up. Running performance and game load were assessed during the first and second half of friendly soccer matches. Absolute running distance, distance covered per minute, distance covered in each of six velocity categories, and game load were tracked during 2 games on 2 consecutive weekends. Data was used only for players that played more than 75% of the game (i.e. 60 minutes, 30 minutes per half). Games were played on field measuring between 50-100 yards in width and 100-130 yards in length, using size ball 5, 11v11 match format (10 field players and 1 goalkeeper), and two half of 40 minutes with 10-15 minutes break between halves.

**Supplement protocol.** The supplementation protocol was administered in a double blind fashion. Twelve U16 female soccer players were randomly assigned to two groups: Sports drink (CHO) or placebo (H20) in order of arrival to the training site. A research assistant was responsible for mixing the supplementation content for each group. The sports drink group ingested Gatorade and Placebo group ingested water mixed with a zero calorie MIO liquid water enhancer. During half time of each game, players were provided with either a 500 ml (Jacobs, I. 1989) of Gatorade or placebo which consisted of 500 ml of water with 1 serving of MIO liquid water enhancer. Players of each group consumed the same liquid at halftime during all games of the first weekend, with the opposite beverage consumed during friendly matches on a subsequent weekend. Gatorade ingredients included: dextrose, citric acid, natural flavor, sodium chloride, sodium citrate, monopotassium phosphate, and flavoring/coloring ingredients. MIO liquid water enhancer ingredients included: Water, Maleic Acid, Propylene Glycol, Citric Acid, Contains Less Than 2% of:, Natural Flavor, Sucralose, Acesulfame Potassium, Potassium Citrate, Red 40, Yellow 5, Blue 1 Lake (CI 42090), Potassium Sorbate. The gatorade group was allowed to ingest water ad libitum during half time as well, and participants were instructed to keep the same diet during both weekends.

**Anthropometric measurement.** Three days prior to the weekend of the first game, the investigator assessed the player's height and weight via Detecto (Webb City MO, USA). This information allowed descriptive analysis of participants.

**Time and Distance.** Minutes played, distance covered, and distance covered per minute were downloaded from the Zephyr biomodule to the computer and exported for analysis. Distance covered was extracted as absolute distance covered (meters) per game. According to previous guidelines, movements on the field were divided in distinct velocity thresholds, and those were defined as: standing 0.0-0.1m/s (0.0-0.36 km/h), walking, 0.1-1.6m/s (0.37–6.0 km/h), jogging 1.69-3.3 m/s (6.1–12.0 km/h); moderate running 3.36-4.3m.s (12.1–15.5 km/h); fast running 4.33-5.55m/s (15.6–20.0 km/h); and sprinting > 5.5 m/s (>20.0 km/h) (Dwyer & Gabbett, 2012; Vescovi & Favero, 2014). High intensity running (HIR) was accounted as ≥3.36 m/s (≥15.5 km/h) and Low intensity running was marked as (LIR) ≤3.36 m/s (≤15.5 km/h) (McCormack et al., 2015; Wells et al., 2015).

**Game load.** Game load was assessed using the training load parameter provided by the Zephyr Analysis software. The internal and external work performed by a player can be assessed using training load. Training load is a summation of the average of the physiological load (summative of all physiological intensity values over the recording period) and mechanical load parameters (summative value of all mechanical intensity values in a given recording period) over the entire recording period.

Physiological intensity was determined through assessment of heart rate data obtained from the bio-module housed in the chest strap. Physiological intensity is a measure that is assessed each second during collection, measured using a continuous scale from 0.0 to 10.0 in arbitrary units of intensity. This value is set up within the Omnisense Live software to register increasing intensity as participants obtain higher $\%HR_{max}$ values. All heart rates detected below $50\%HR_{max}$ are reported as 0.0, while all heart rates detected at or above $100\%HR_{max}$ are reported as 10.0. All intensity values are corresponding intensity values on a 0.0 to 10.0 scale (e.g. 60% $HR_{max}$ would correspond to 2.0, 85% would correspond to 7.0, etc.). Mechanical intensity was determined through assessment of accelerometry measures obtained from tri-axial accelerometers located within the biomodule. Mechanical intensity was measured each second and reported in arbitrary units of intensity from 0.0 to 10.0, based on g-forces measured from accelerometers, where 0.0g was reported as 0.0 and 5.5g or greater was reported as 10.0. Data was stored internally within the biomodule and downloaded after each game for analysis.

**Food record.** Each participant was asked to keep a food log to maintain consistency in diet. Participants were asked to provide a three day food record (two week days and a weekend day) during the weekend prior to the games, and on Friday, Saturday and Sunday of each weekend when the games was played. At the beginning of the study, participants were educated on how to use the MyFitnessPal app. All subjects were instructed to log food records into a smartphone App (“MyFitnessPal”), and share their food record with the principal investigator of the study. The purpose of these food records was to ensure that participants consumed a similar diet (including liquids such as caffeine and carbohydrate drinks) during both weekends, and no major changes in the diet occurred during the time of the study. The principal investigator was looking for consistency in macronutrients. If any participant had any major changes in the diet, they were informed on the importance of keeping a normal diet throughout the study.

**Procedures**

Prior to each game, participants were fitted with a Zephyr bioharness (Model BH3, Zephyr Technology Corporation, Annapolis, MD, USA), and a 10Hz global positioning receiver/transmitter (BT-Q818XT, QStarz, Taipei, Taiwan). When using a criterion three lead ECG, Zephyr heart rate sensors have been previously validated for use during exercise (Johnstone et al, 2012). T he bioharness is a wireless, ambulatory physiological monitoring device that consists of a chest strap and battery operated monitoring device (biomodule) (Johnstone et al, 2012). The biomodule attaches to a receptacle in the chest strap and captures heart rate data through conductive fabric skin electrode sensors housed in the chest strap, and functions as a transmitter and data logger. Additionally, the biomodule contains a tri-axial accelerometer sampling at 100Hz, and integrates real time GPS data sampled at 10 Hz (and logged at 1Hz) and transmitted via Bluetooth. Previous research has shown 1 Hz GPS to be valid and reliable for total distance in soccer specific movements (Johnstone et al., 2012).

**Study Time-Line**

**Week 1.**

Parents received a recruitment letter via email and verbal communication during practice about the nature of the study, including the purpose, hypotheses, and exclusion criteria to participate. During the same week, an informational meeting was held with all the parents and players who were interested in participating in the study. This meeting was provide parents and players with the purpose of the study, details on the methodology, including what exercise protocol would be used testing, what sports drink would be used, and a detailed description of the time line for the study. This allowed potential participants and parents to decide whether they were able and willing to participate. In addition, this meeting allowed potential participants and players to ask questions regarding the study. Those who decide to participate were given a health questionnaire, minor consent form, and a parental consent form. These forms were completed in full, signed and turned into the principal investigator. During this time, participants were given information about tracking food intake via “MyFitnessPal.”

**Week 2.**

*Wednesday*- Weight and height was assessed before practice, and BMI was calculated.

*Friday*- Players shared with the principal investigator their food record via MyFitnessPal with the principal investigator.

*Saturday*- Principal investigator and research assistant arrived at game location 35 minutes before players start began warm up so they could fit the Zephyr bioharness on each player correctly without interfering with the warm up. Players warm up started 45 minutes before kickoff. Additionally, players shared food record with the principal investigator via MyFitnessPal.

*Sunday*- Principal Investigator and research assistant arrived at game location 35 minutes before players start began warm up so they could fit the Zephyr bioharness on each player correctly without interfering with the warm up. Players warm up started 45 minutes before kickoff. Additionally, players shared food record with the principal investigator via MyFitnessPal.

**Week 3:**

*Friday*- Players shared their food record via with principal investigator via MyFitnessPal.

*Saturday*- Principal Investigator and research assistant arrived at game location 35 minutes before players start began warm up so they could fit the Zephyr bioharness on each player correctly without interfering with the warm up. Players warm up started 45 minutes before kickoff. Additionally, players shared food record with the principal investigator via MyFitnessPal.

*Sunday*- Principal Investigator and research assistant arrived at game location 35 minutes before players start began warm up so they could fit the Zephyr bioharness on each player correctly without interfering with the warm up. Players warm up started 45 minutes before kickoff. Additionally, players shared food record with the principal investigator via MyFitnessPal.

**Statistical Analysis**

The data are expressed as means ± standard deviation. Data were analyzed using statistical package SPSS (SPSS Inc. Released 2010. SPSS for Windows Version 19.0 Chicago, SPSS Inc). Prior to statistical procedures, all data were assessed for sphericity. If the assumption of sphericity was violated, a Greenhouse-Geisser correction was applied. Statistical analysis of performance data were accomplished using a 2x2 [treatment (supplementation vs. placebo) x half] repeated-measures ANOVA. In the event of significance F ratio, least significant difference post hoc tests were used for pairwise comparison. If a significant interaction was observed, dependent t-tests were used for pairwise comparisons between treatments at each time point. Time effects were further analyzed using partial eta squared (partial $\eta^2$). Interpretations of partial $\eta^2$ were evaluated in accordance with Cohen (Cohen, 1988) at the following levels: small effect (0.01–0.058), medium effect (0.059–0.137) and large effect (>0.138). Data from the first weekend were combined with data from second weekend. Statistical significance was set as $p \leq 0.05$.

# CHAPTER 4

# RESULTS

## Descriptive Analysis

While 12 players initially took part in the study, only six players were included in the analysis. From 12 players, six players had to be excluded from the study for failing to meet the playing time's inclusion criteria (30 minutes per half in all games). See table 1 for physical characteristics of players included in this study.

**Table 1. Physical characteristics of the players participating in the study (n=6).**

| Variables | *n* | *Mean* | *(±SD)* |
|---|---|---|---|
| Age (years) | 6 | 15.97 | 0.45 |
| Height (cm) | 6 | 159.62 | 5.35 |
| Body Mass (kg) | 6 | 54.87 | 4.25 |
| BMI ($kg \cdot m^{-2}$) | 6 | 21.59 | 2.10 |

## Minutes Played

Changes in total distance covered are presented on Table 2. ANOVAS showed a significant time x treatment interaction, $F(1.00, 11.00)= 8.247$, $p=.015$, partial $\eta^2= 0.042$. Post hoc analysis test indicated that the mean score for placebo condition in the first half ($M= 36.40$, $SD= 4.97$) decreased to towards to the second half ($M=32.73$, $SD=2.96$)1, and it was significantly different than treatment which had a mean score of $M=34.79$ ($SD= 3.92$) in the first half and the mean $M=37.49$ ($SD=4.22$) increasing towards to the second half with an observed power of 0.74. Also, a trend of main effect of treatment was also noted $F(1.00,11.00)=4.127$, $p=.067$, *partial* $\eta^2=0.27$, with mean score of $M= 34.56$ ($SD= .77$) for placebo and $M=36.14$

(*SD*=1.06) for supplementation with an observed power of .45. Dependent t-tests were used for pairwise comparisons between treatments at each time point, significant changes were found between treatments in the second half (*p*=.005). However, no significant main effect for half (*p*=.611) was observed.

**Distance Covered**

Changes in total distance covered are presented in Table 2. ANOVAs showed no time x treatment interaction (*p*=0.121) or main effect for treatment (*p*=0.640). However, there was a trend for main effect for half, $F(1.00, 11.00)= 3.567$, $p=.086$), partial $\eta^2=0.24$, where total distance covered decreased in the second half (*M*=3138, *SD*=98.87) compared to the first half (*M*=3379.371, *SD*=140.28), with an observed power of .40. Dependent t-tests were used for pairwise comparisons between halves for each treatment, a trend for significance changes were found between halves for placebo (*p*=.076).

**Velocities**

**Walking.** Changes in distance covered in each velocity are presented Table 2. ANOVAs of walking speed showed a significant time x treatment interaction, $F(1.00;11.00)= 11.026$, $p= .007$ $\eta p^2= .50$**,** and half, $F(1.00, 11.00) = 5.715$, $p=.036$, partial $\eta^2=0.34$. Supplementation group covered a distance in first half mean score of *M*=648.86 (*SD*=360.90) and in the second half *M*=1167.11 (*SD*= 622.23) which was a significant higher walking distance when compared to placebo group (first half *M*=681.55, *SD*=331.87; second half *M*=1007.54, *SD*=562.66), with an observed power of 0.85. Additionally, players covered a significant lower distance in the first half (*M*=844.54, *SD*=54.37) comparing to the second half (*M*=907.99, *SD*=51.88), with an observed power .58. Dependent t-tests were used for pairwise comparisons between halves for each treatment, significant changes were found between halves for supplementation ($p$=.002).

**Jogging.** No significant time x treatment interaction ($p$=.131) or main effect for treatment ($p$=.657) or half ($p$=0.170) was noted at jogging speed.

**Moderate running**. In moderate running speed, no significant time x treatment interaction ($p$=0.929) or main effect of treatment ($p$=0.388) was noted. However, a trend towards a main effect for half was observed, $F$(1.00,11.00)= 4.582, $p$=.056, partial $\eta^2$=0.29, where first half distance covered ($M$=499.04, $SD$=34.99) at moderate running speed was higher than the second half ($M$=438.77, $SD$=29.76), with an observed power of 0.49, this effect was considered very large.

**Fast running.** No significant time x treatment interaction ($p$=.348) or main effect of treatment ($p$=.754) was noted at fast running speed. However, a significant main effect for half, $F$(1.00, 11.00) = 6.807, $p$= 0.024, partial $\eta^2$=0.38, was noted. Distance covered decreased in the second half ($M$=379.53, $SD$=25.41) when compared to the first half ($M$=454.16, $SD$=26.22) in fast running speed, with an observed power of 0.66. Dependent t-tests were used for pairwise comparisons between halves for each treatment, trend for significance changes were found between halve for placebo ($p$=.087).

**Sprinting.** No significant time x treatment interaction ($p$>.146) was noted for sprinting speed. However, a trend towards a main effect for treatment was noted, $F$ (1.00, 10.00) = 4.244, $p$=.066, partial $\eta^2$=0.29, which placebo had a mean score of $M$=536.82 ($SD$=95.09) while supplementation had a mean score of $M$=223.00 ($SD$=61.89), with an observed power of 0.46. A significant main effect for half, $F$(1.00, 10.00)= 30.862, $p\leq$0.001, partial $\eta^2$=0.75, was noted with a decrease in distance covered at sprinting speed in the second half ($M$=314.01, $SD$=19.15) comparing to first half ($M$=445.81 $SD$=34.22), with an observed power of 0.99, this effect was considered large. Dependent t-tests were used for pairwise comparisons between halves for each treatment, significant changes were found between halves for placebo ($p$=.01).

**Low-intensity running.** There was a significant time x treatment interaction, $F$(1.00, 11.00)= 7.275, $p$= .021 , partial $\eta^2$= 0.39, at low-intensity running, with an observed power of 0.69. The supplementation group covered a higher distance in both halves and had an increase in distance covered in the second half (first half $M$=2099,73, $SD$=188.29; second half $M$=2245.04, $SD$=205.11), while placebo group decrease distance covered in the second half compared to the first half (first half $M$=1905.24, $SD$=187.60; second half $M$=1726.27, $SD$=186.24). No other significant interaction (half, $p$=.827; treatment, $p$=.317) was found at low-intensity running speed.

**High-intensity running.** No significant time x treatment interaction ($p$>.163) or main effect for treatment ($p$=.220) was noted at high-intensity run speed. However, a significant main effect for half, $F$(1.00, 10.00) = 19.648, $p \leq$.001, partial $\eta^2$=0.66, distance covered decreased in the second half ($M$=123.23, $SD$=890.01) compared to first half ($M$=560.44, $SD$=1311.32) at high-intensity run, with an observed power 0.05. Dependent t-tests were used for pairwise comparisons between halves for each treatment, significant changes were found between halves for placebo ($p$=.019).

**Game load**

Changes in game load are presented Table 2. Analysis of variances showed no time x treatment interaction (*p*=0.112) or main effect for treatment (*p*=0.835). However, there was a trend for main effect for half, $F(1.00, 11.00) = 4.249$, $p=.064$, partial $\eta^2=0.27$, with an observed power 0.46, where game load decreased in the second half (*M*=131.22, *SD*=5.8) compared to first half (*M*=142.18, *SD*=8.17), this effect was considered large.

**Table 2. Absolute distance covered during first and second half.**

| **Variables** | | **Time** | | |
|---|---|---|---|---|
| Absolute Distance (m) | Trial | First Half | Second Half | Game |
| Minutes Played | Supplement | 34.79±3.92 | 37.49±4.22 | 72.28±4.07[φ] |
| | PLA | 36.40±4.97 | 32.73±2.96 | 69.13±3.96[φ] |
| TD | Supplement | 3296.83±444.75 | 3312.23±440.23 | 6609.06±442.49 |
| | PLA | 3461.90±819.4773 | 2965.33±591.52* | 6427.23±705.49 |
| Walking | Supplement | 1007.54±562.67 | 1167.11±622.23* | 2174.65±592.45[φ] |
| | PLA | 681.55±331.87 | 648.86±360.91 | 1330.41±346.39[φ] |
| Jogging | Supplement | 1092.18±301.39 | 1077.93±300.46 | 2170.11±300.93 |
| | PLA | 1223.69±403.21 | 1077.41±326.23 | 2301.10±364.72 |
| Moderate Running | Supplement | 527.13±183.48 | 468.98±147.96 | 996.11±165.72 |
| | PLA | 470.95±195.60 | 408.55±118.26 | 879.50±156.93 |
| Fast Running | Supplement | 417.01±267.01 | 376.15±208.85 | 793.16±237.93 |
| | PLA | 491.30±298.43 | 382.91±182.83* | 874.21±240.63 |
| Sprinting | Supplement | 273.45±255.75 | 218.41±174.17 | 491.86±214.96 |
| | PLA | 644.02±403.14 | 395.32±247.86* | 1039.34±325.5 |
| LIR | Supplement | 2099.73±652.28 | 2245.04±710.54 | 4344.77±681.41[φ] |
| | PLA | 1905.24±649.89 | 1726.27±645.15 | 3631.51±647.52[φ] |
| HIR | Supplement | 1193.65±640.66 | 1063.56±460.48* | 2257.21±550.57 |
| | PLA | 1667.86±722.03 | 1186.79±400.67 | 2854.65±561.35 |
| Game Load (AU) | Supplement | 136.48±23.74 | 138.66±27.69 | 275.14±25.71 |
| | PLA | 147.88±46.77 | 123.78±19.56 | 271.66±33.16 |

Note: Data are presented as means ± SD. TD, total distance; HIR, high-intensity running; LIR, low-intensity; PLA, placebo

*Significant between halves

[ɨ]Significant between treatment

[φ]Significant between halves x treatment

**Distance covered per minute**

Changes in total distance covered per minute and distance covered per minute in each velocity are presented on Table 3. Analysis of variances showed no significant time x treatment interaction (*p*=.583), treatment (*p*=.910), and main effect of half (*p*=.667) for total distance covered per minute. No time x treatment interaction (*p*=.71) or main effect for treatment was noted (*p*=423) in walking distance per minute. However, there was a trend for main effect for half, $F(1.00, 11.00) = 4.338$, *p*=.061, partial $\eta^2$=0.28, with an observed power of 0.47, where walking distance covered per minute increased in the second half (*M*=34.15, *SD*=2.73) compared to the first half (*M*=29.39, *SD*=2.15), this effect was considered large. No significant time x treatment interaction (*p*=.398), treatment (*p*=.671), or main effect of half (*p*=.713) was noted for jogging distance covered per minute. Similarly, no significant time x treatment interaction (*p*=.201treatment (*p*=.449) or main effect of half (*p*=.20) was noted for moderate running. No significant time x treatment interaction (*p*>.480); treatment (*p*=.871) or main effect of half (*p*=.189) was noted for fast running distance covered per minute. Sprinting distance covered per minute also did not show any significant time x treatment interaction (*p*=.85), treatment (*p*=.19), or main effect of time (*p*=.256). No significant time x treatment interaction (*p*=.710), treatment (*p*=.802), or main effect of half (*p*=.508) was noted at low- intensity running, and no time x treatment interaction (*p*=.252), treatment (*p*=.462), or main effect of half (*p*=.68) was noted at high-intensity running.

**Table 3. Distance covered per minute during first and second half**

| **Variables** | | **Time** | | |
|---|---|---|---|---|
| Relative Distance (m/min) | Trial | First Half | Second Half | Game |
| TDREL | Supplement | 130.55±59.42 | 119.99±49.72 | 125.27±59.98 |
| | PLA | 122.07±58.68 | 124.14±52.20 | 123.89±59.09 |
| Walking | Supplement | 33.24±14.60 | 38.89±22.88 | 36.06±14.86 |
| | PLA | 25.55±20.19 | 29.41±22.15 | 27.48±20.50 |
| Jogging | Supplement | 43.56±24.06 | 39.44±18.67 | 41.5±24.30 |
| | PLA | 44.77±29.18 | 46.33±25.07 | 45.44±29.48 |
| Moderate Running | Supplement | 23.02±16.50 | 17.72±10.82 | 20.15±16.64 |
| | PLA | 17.26±11.02 | 17.31±7.76 | 17.28±11.10 |
| Fast Running | Supplement | 18.48±16.65 | 14.60±12.33 | 16.54±12.81 |
| | PLA | 15.98±11.68 | 15.18±7.04 | 15.58±11.73 |
| Sprinting | Supplement | 12.10±13.98 | 9.19±10.13 | 10.64±15.30 |
| | PLA | 20.05±15.60 | 15.55±12.37 | 18.60±16.42 |
| LIR | Supplement | 76.8±29.20 | 78.33±32.93 | 77.89±29.55 |
| | PLA | 70.31±48.25 | 75.84±45.28 | 71.43±48.84 |
| HIR | Supplement | 53.62±41.28 | 41.52±30.08 | 47.57±47.44 |
| | PLA | 53.85±32.41 | 48.04±20.08 | 50.07±34.71 |

Note: Data are presented as means ± SD. TD, total distance; HIR, high-intensity running; LIR, low-intensity; PLA, placebo
*Significant between halves
ᵼSignificant between treatment
φSignificant between time x treatment

## Games Results

Results of all four games are presented on table 4.

**Table 4. Competition Schedule and Results**

| Saturday | Results | Assessed-team match outcome |
|---|---|---|
| 1 | 4-0 | Won |
| 2 | 6-0 | Won |
| Sunday | | |
| 1 | 4-3 | Won |
| 2 | 0-1 | Lost |

# CHAPTER 5

# DISCUSSION

This study's primary purpose was to investigate the effect of a sports drink ingested during half time on second half performance during a competitive weekend in U16 female soccer players. In this study, performance was assessed through changes in running velocity, distance coverage and game load. The results of this study revealed that the consumption of a sports drink did not significantly influence total distance covered. Despite a significant higher distance covered at walking speed, this study observed a significant treatment x time interaction between groups on minutes played. Treatment group played a higher amount of minutes in the second half, consequently, distance covered at walking distance and low-intensity running speed was influenced as well. In contrast to what was expected, no significant treatments x time interactions for any other running velocities were observed. Despite the lack of significance found between groups, a decrease in fast speed, sprinting and high intensity running  performance was observed from first half to second half,. Consequently, game load also decreased between halves while walking and jogging increased significantly throughout the game. No significant results were found at distance covered per minute.

Youth soccer has grown extensively in the United States, and among youth team sport, mainly male soccer players, have received attention from coaches, exercise practitioners, and researchers (Atan, Foskett & Ali, 2014; Mendez-Villanueva, Buchheit, Simpson &Bourdon 2012). The US Youth Soccer has determined different playing time, match format, field size, and ball size between youth age levels. However, U16 soccer players perform in the same size of field, ball size, and match format then collegiate or professional soccer players. The only difference is U16 games usually have unlimited substitutions and games composed of two halves of 40 minutes with 10-15 minute break between halves, instead of 2 halves of 45 minutes (US Youth Soccer, 2012). Consequently, one of the challenges faced in this study was to maintain players in the inclusion criteria of 30 minutes per half in every game. The limited amount of subjects in this study was mainly because of the unlimited substitution rule for this age group.

When using GPS, performance is expressed in distance covered at different movement intensities. A standardized velocity threshold is necessary to allow comparison between studies. A study conducted with elite youth soccer players used the mean of 10 m sprint to assess the motion demands of elite youth soccer players in the U12 to U16 age-groups (Harley et al., 2010). Speed zones used for U16 soccer players were divided in: standing (0.46 $m{\bullet}s^{-1}$), walking (1.83 $m{\bullet}s^{-1}$), jogging (3.66 $m{\bullet}s^{-1}$), running (5.04 $m{\bullet}s^{-1}$), high-speed running (6.41 $m{\bullet}s^{-1}$), and sprinting (6.41 $m{\bullet}s^{-1}$). Post-game analysis enabled the quantification of total distance covered (sum of zones 1–6), and distance covered at high-intensity (zones 4, 5, and 6), very high- intensity (zones 5 and 6), and at sprinting pace (zone 6) (Harley et al., 2010). This parallels to the current study using the same age group. Additionally, Harley et al., (2010 ) study found that match-play demands appear to be consistent across the ages, however, players become significantly faster in U14 and U15 age groups when compared to younger ages (Harley et al., 2010). Similar to Harley's study, the present study also found discrepancy between ages. The youngest player included in the study (recently turned 15) did not reach sprinting speed in one of the games. This was unusual between subjects, and that subject was the only one unable to perform in a higher speed zone, which could have potentially influenced the results of the study. However, the current study observed that there were no complaints from the participants about wearing the GPS harness.

Due to limited published studies in female youth soccer players, less is known about differences between age groups and patterns across ages. Youth soccer players cover an average of 5-10 km during the game (Arruda et al., 2015; Buchheit et al., 2010; Harley et al., 2010; Vescovi & Favero, 2014). In the present study, distance covered had an overall mean of 6518.14m, regardless of group assessed. When examining distance covered in each half for all the games, the supplementation group covered a mean of 3296.83m (*SD*=444.75) in the first half and 3312.23m (*SD*=440.23) in the second half. Similar to the supplementation group, the placebo group covered 3461.90m (*SD*=819.47) in the first half and 2965.33m (*SD*=591.52) in the second half, showing that both groups had a significant decrease between halves. When examining youth soccer players (ten male U-15 soccer players of 15.1 years *SD*=1.02) Arruda et al., (2015), found distance covered was between 4-7 km per game. Similar results were observed in the present study, showing that youth female soccer players covered a similar total range of distance than males youth soccer players. Another study that used GPS technology on 10 female soccer players found a mean of distance covered of per minute of 119.96 $m \cdot min^{-1}$ (*SD*= 8.01) on Friday's games and 116 (*SD*=8.10) on Saturday's games. Subjects were recruited from Division I college and players aged 20.5 years (*SD*=1.0), height of 166.6 cm (*SD*=5.1), and body mass of 61.1 kg (*SD*=5.8), and games played on Friday evenings and Sunday during regular season were analyzed (McCormack et al., 2014). Another study with collegiate females soccer players of age 21.3 years (*SD*=0.9), height of 170.3cm (*SD*=5.7), body mass of 64kg (*SD*=5.8) found a mean of 7481.96m (*SD*=958.57) also during regular season games (Wells et al., 2015). Similar to these studies, the present study used GPS technology to analyze total distance and total distance covered per minute. Although slight differences in total distance covered were found between the present study and past research (Arruda et al., 2015; Buccheit et al., 2010), total distance covered per minute ranged from 80-130 m/min is similar to Arruda et al., (2015) (90-120m/min) McCornack et al., (2014) (108-125 m/min), and Wells et al., (2015) (97-104m/mim) suggesting that there is no main differences in total distance covered per minute between U16 female soccer players and youth male soccer players or collegiate female soccer players.

Despite the importance of covering longer distance during the game, soccer is also a sport associated with frequent intermittent high- intensity exercise. In elite level players, the combination of high intensity running and sprinting is reported to account for approximately 10% of the total distance covered during a competitive match (Mohr, Krustrup, & Bangsbo 2003). To maintain possession of the ball, sprint to score a goal, or urgency to defend, high-intensity running are necessary for successful performance (Harley et al., 2010; Mohr, Krustrup, & Bangsbo 2003). In contrast with total distance covered, sprinting ability is age and position-dependent in young soccer players (Buccheit, Mendez-Villanueva, Simpson, 2010; Buccheit et al., 2012; Haddad at al., 2015; Mendez-Villanueva et al., 2011; Vescovi, Rupf, Brown, & Marques, 2011). The present study found a decrease in performance from first half to second half in fast running, sprinting and high intensity running speed. Similar results were found when analyzing female soccer players (McCormack et al., 2014; Wells et al., 2015). However, both of these studies examined collegiate age soccer players, and different from the present study McCormack et al., (2014), found decreases in sprinting performance between games separated within less than 42 hours (the present study had games within less than 24 hours). Well et al., (2015) found a decreased in HIR and fast sprinting in the second half, however also found a decreased in LIR and walking distance in the second half which differed from the present study that found an increased in both of these velocities in the second half.

The American College of Sports Medicine recommends 3 to 8 ounces (80-250ml) of sports drink every 15-20 minutes when exercise is longer than 60 minutes (ACSM, 1996). However, this recommendation is not realistic during soccer games, because there are no scheduled breaks during the match except half-time. This prevents players from consuming sports drink during the game. One study found that if sufficient carbohydrate-electrolyte solution is consumed before and at half-time, sprint performance and metabolism are not significantly affected when compared to consuming the same total volume ingested at the recommended 15-min intervals (Convertino et al., 1996). In another study similar to Convertino et al., (1996), also found no differences between thirst or gut fullness between trials (Clarke et al., 2005). Consequently, the present study met a practical strategy for fluid provision during a soccer game, refueling and rehydrating players participating of this study. Additionally, all players were allowed to ingest water ad libitum during half time, if any extra water or carbohydrate drink was ingested before or during the game, players were asked to maintain the same strategy in the following games. There were no complaints about the amount of liquid (500 ml of Gatorade or flavored water) that needed to be ingested or the taste of the drink that players drank during the half time break.

It is believed that ingesting a carbohydrate drink during a game could potentially attenuate decreases in performance, improve or maintain soccer skill performance, and attenuate decreases in muscle glycogen concentration from maintaining available exogenous glucose sparing glycogen or endogenous stores, allowing players to perform better (Ali&Williams, 2009; Goedeck et al., 2013, Guerra, Chaves, Barros & Tirapegui, 2004; McGregor et al 1999; O'Reilly &Wong, 2013; Ostojic & Mazic, 2002; Russell, Benton, & Kingsley 2014). The decline in glycogen stores is associated with lower running speeds, and shorter distances covered during the second half when compared to the first half of a match (Saltin 1973). This may also be accompanied by reduced sprint performance (Krustrup et al. 2006). As already mentioned, in contrast to what was expected, the present study did not found time x treatment interaction in any of the velocities consisted in HIR or HIR. However, significant time x treatment interaction was observed for low intensity running and walking distance. Supplementation group covered a significant longer walking distance when compared to placebo group in the second half. This may be a result of differences in minutes played between treatments, where the supplementation group played significantly more minutes than placebo, and also, increased minutes played in the second half while placebo decreased minutes played. Longer playing time in the field may have stimulated fatigue for the supplementation group, consequently influencing negative sprinting performance and increasing LIR and walking distance.

To date, there are no known published studies that have examined the effect of sports drink ingestion in youth female soccer on performance using HR/ GPS harness in the same group during real games. Past research has examined the effect of carbohydrate ingestion on performance in professional or male youth soccer players, but not in youth or female soccer players (Ali & Williams, 2009; Goedeck et al., 2013; Guerra, Chaves, Barros & Tirapegui, 2004; O'Reilly &Wong, 2013; Russell, Benton, & Kingsley, 2014). Most of these studies observed adult male soccer players used soccer skills test such as Loughborough Soccer Passing Test (LSPT) (Ali & Williams, 2009; Goedeck et al., 2013; O'Reilly &Wong, 2013). O'Reilly &Wong (2013) conducted a crossover study design with groups ingesting 2 mL of fluid per/kg body mass of 6.6% CHO-electrolyte drink or the same amount of placebo every 15 minutes during exercise, and found that consuming CHO drinks resulted in a significant improvement in movement time and overall LSPT performance. They concluded that ingestion of carbohydrate during exercise could improve post-exercise skill performance. Similarly, another study used seventeen adult male soccer players divided in two groups (Ali & Williams, 2009). Each group ingested CHO, or placebo solution equivalent to 8 ml •$kg^{-1}$ body mass before testing, and 3 ml•$kg^{-1}$ body mass after and every 15 minutes of exercise. This study found a significant difference on time with differences between 0-45 and 75-90 minutes. Both groups showed a reduction of skill performance before, during, and after the exercise; however, in the CHO group reduction was 3% and placebo trial performance decreased 14 %. Despite the decrease in performance in the last 15-30 min of exercise, Ali & Williams (2009) study concluded that providing 52g•$h^{-1}$ carbohydrate drinks during the exercise could better maintain soccer skill performance when compared to placebo group. In another study, (Goedeck et al., 2013), investigated how 700 ml of 7% carbohydrate solution could affect performance in postprandial soccer players when compared to a placebo during a simulated soccer match. Twenty trained male soccer players completed two trial separated by 7 days, concluding that when adjusting for body mass, increasing CHO intake was associated with an improved time to fatigue during the simulated soccer match (Goedeck et al., 2013). In contrast to these studies, the present study did not use a simulated game or soccer passing drill to evaluate performance. The fact that the population used for the current study is highly sprinting age- dependent and the contextual factor of the match could have had an influence on player's performance, perhaps using a simulated game or a soccer passing drill could have shown better results with the use of supplementation. Additionally, trends observed in the present study could be clearer if soccer passing drills were used. The present study found a trend in differences in performance between halves in moderate running and distance covered. Distance covered decreased in the second half while moderate running distance increased in the second half. Of all six velocities, walking increased significantly, jogging had no changing between halves, moderate running had a trend to increase in the second half while fast running and sprinting significantly decreased in the second half. Moderate running velocity in this study consisted of 3.36-4.3m.s (12.1-15.5 km/h). Our findings indicate that moderate speed running is the transition speed for those players who are comfortable to perform in a more anaerobic base than those who perform mainly in an aerobic base. Still, the range used for moderate running was lower than Well et al., (2015) which used 3.61-4.43 $m.s^{-1}$ instead of 3.36-4.3$m.s^{-1}$. However, in Wells et al., (2015) study subjects consisted of female collegiate soccer players, which may suggest that age differences between youth and collegiate players can be important in performance and also small differences in speed when using GPS analysis has to be examined closer. Another explanation of the discrepancies between youth and collegiate players is the level of pressure player in college have compare to youth ages. The urgency to perform and the substitution rules may influence player's performance. In the collegiate levels players could potentially perform in a higher speed for longer time. Regardless of the ability from the players in this study to reach the sprinting speed that was similar used in collegiate levels, the subjects of the present study could not maintain on that speed for a similar distance or the age between players (14, 15, and 16 years old) may had brought discrepancies between players.

There have only been a few studies utilizing game realistic scenarios to analyze the influence of carbohydrate or sports drink (carbohydrate and electrolytes) ingestion in youth soccer players (Guerra, Chaves, Barros & Tirapegui, 2004; Russell, Benton, & Kingsley, 2014). One of these studies specifically examined carbohydrate ingestion before and during a soccer match, investigating exercise-induced rebound glycemic response through blood glucose and lactate concentration, and did not account for performance. This study used ten male outfield academy soccer players (age =15.6±0.2 years) in a crossover study, and concluded that ingestion of a 6% CHO-electrolyte beverage before and during a soccer match did not show potential benefits during second half of the soccer game, indicating that supplementation did not influence the pattern of response (time x treatment interaction effect $p = 0.49$) (Russell, Benton, & Kingsley, 2014). In another study using youth soccer players and accounting for performance, the influence of fluid ingestion on performance of soccer players during a match was observed (Guerra, Chaves, Barros & Tirapegui, 2004). Twenty male youth soccer players of 16.01 years (*SD*=1.11) participated in the CHO beverage intervention during a 75 minute game (45 minutes half, 15 minutes of interval followed by 30 minutes half). Players were divided in two groups (CHO or water-NCHO). CHO groups (n=10) ingested Gatorade (6% CHO solution) every 15 minutes during the game; both groups were allowed to ingest water ad libitum during halftime. Heart rate (Polar Sport Tester S610, Finland) and core temperature (Cor Temperature Disposal Temperature Senson and Cor Temp 2000) were assessed every 15 minutes during the match. Performance was measured during the game from observation of twenty volunteers, and core temperature was assessed every 15 minutes as well. During the second half, HR of NCHO (n=10) group was higher compared to CHO groups ($p<0.05$). Additionally, during the first half CHO group performed more sprints than NCHO group ($p<0.05$), concluding that carbohydrate beverage indicates to be beneficial on preventing deterioration in performance (Guerra, Chaves, Barros & Tirapegui, 2004). In contrast to both of these studies, the current study made use of GPS technology to measure performance. Similar to Russell, Benton, & Kingsley, 2014, results showed that supplementation (sports drink, Gatorade) ingestion was not beneficial on preventing deterioration in performance in high-intensity running. However, it is thought that in this age group, the contextual factor of the match had influence in player's performance, similar to past research (Anderson, Vescovi, Arruda et al., 2015; Edwards et al, 2007; Lago et al, 2010; Mohr, Krustrup, &Bangsbo, 2003). Because the nature of this study, where players are involved in both trials (supplementation and placebo), their position was not relevant for differences between supplementation and placebo. In fact, distance covered in each velocity and game load could be more influenced by the flow, intensity and results of the games than player's performance or group trial. Examining all scores of the games on Table 4, one of the games was a 0x1 lost. Usually, the game with a lost, players from the back line (defenders) are possibly more involved in the game, and in this game both center backs were part of the placebo group. This could explain the trend for the placebo group covering a longer distance on sprinting speed in the second half. Youth female soccer players need to receive more attention about players position and age demand, and the consequences in performance throughout tournaments and congested schedules, more specifically on their performance in the second half towards the end of the game.

This study examined the influence of sports drink ingestion during halftime break in performance in U16 soccer players across a weekend of games. Consequently, from 12 players recruited only six were eligible (playing time ≥30 minutes per half for all the games) for data analysis. The results of this study should be interpreted carefully in consequence of the limited sample size. Also, differences between age, position and game intensity may have influence player's performance. For future studies, it is suggested that the player's diet, position, RPE for each game, game results, game intensity, team strategies, and player's biological and chronological age are assessed.

The results of the current study concluded that consuming sports drink have no benefit on preventing deterioration in performance. Overall, sports drink does not influence youth female soccer players performance throughout a weekend of games. However, player’s characteristic and game results may potentially have a higher impact on player performance than the drink. Furthermore, ingestion liquids as sports drink during half time could potentially help players avoid dehydration throughout the weekend.

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# APPENDIX A

## INFORMED CONSENT

1. My name is Nadima Skeff, I am a second year Sports Nutrition graduate student at Georgia Southern University. This research study will attempt to determine the effect of half time sports drink ingestion on subsequent half performance in U16 female soccer players during consecutive matches

2. Purpose of the Study: The purpose of this study is to evaluate effects of sports drink ingestion during halftime on subsequent half performance specifically in U16 female soccer players. The secondary purpose is to evaluate the effect of sports drink ingestion on performance decrement across a competitive weekend of youth soccer matches.

3. Procedures to be followed: Participation in this research will require individuals to report to the Jennifer Ross Soccer Complex for pre testing (Wednesday) and post testing (Monday). The exercise and supplementation protocol (description bellow) will be performed in the game location according to team's schedule. During the course of study, you will train in the same location you always train, and supplementation will be given to you in the game location of that day.

   **Study Schedule:**

   <u>Week 1:</u>
   You and your child will receive a recruitment letter via email and verbal communication during practice about the nature of the study, including the purpose, hypotheses, and exclusion criteria to participate. During the same week, an informational meeting will be held with all the parents and players who are interested in participating in the study. This meeting will provide parents and players with the purpose of the study, details on the methodology, including what exercise protocol will be used, when testing dates will take place, what sports drink will be used, and a detailed description of the time line for the study. This will allow potential participants and parents to decide whether they are able and willing to participate. In addition, this meeting will allow you and your child to ask questions regarding the study. If you decide to participate, you will be given a health questionnaire, minor assent form, and a parental consent form. These forms will be completed in full, signed and turned into the principal investigator. They will also be given information about tracking food intake via "MyFitnessPal."

   <u>Week 2:</u>

*Wednesday*- Weight and height will be assessed before practice, and BMI (Body Mass Index) will be calculated (at Jennifer Ross Soccer Complex).

*Friday*- Players will share with the principal investigator their food record via MyFitnessPal.

*Saturday*- Principal investigator and research assistant will arrive at game location 35 minutes before the players start to warm up so they can fit the Heart Rate GPS (Zephyr bioharness) on each player correctly without interfering with the warm up. Players warm up will start 45 minutes before kickoff. Additionally, players will complete POMS questionnaire before and after the game, also a RESTQ76 questionnaire only in the end of the game. During the day, players will share food record with the principal investigator via MyFitnessPal

*Sunday*- Principal investigator and research assistant will arrive at game location 35 minutes before the players start to warm up so they can fit the Heart Rate GPS (Zephyr bioharness) on each player correctly without interfering with the warm up. Players warm up will start 45 minutes before kickoff. Additionally, players will complete POMS questionnaire before and after the game, also a RESTQ76 questionnaire only in the end of the game. During the day, players will share food record with the principal investigator via MyFitnessPal

<u>Week 3:</u>
*Friday*- Players will share their food record via with principal investigator MyFitnessPal.

*Saturday*- Principal investigator and research assistant will arrive at game location 35 minutes before the players start to warm up so they can fit the Heart Rate GPS (Zephyr bioharness) on each player correctly without interfering with the warm up. Players warm up will start 45 minutes before kickoff. Additionally, players will complete POMS questionnaire before and after the game, also a RESTQ76 questionnaire only in the end of the game. During the day, players will share food record with the principal investigator via MyFitnessPal

*Sunday*- Principal investigator and research assistant will arrive at game location 35 minutes before the players start to warm up so they can fit the Heart Rate GPS (Zephyr bioharness) on each player correctly without interfering with the warm up. Players warm up will start 45 minutes before kickoff. Additionally, players will complete POMS questionnaire before and after the game, also a RESTQ76 questionnaire only in the end of the game. During the day, players will share food record with the principal investigator via MyFitnessPal

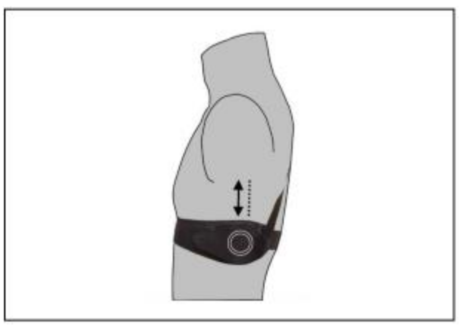
**Supplementation will be handled during half time of each game on both weekends.**

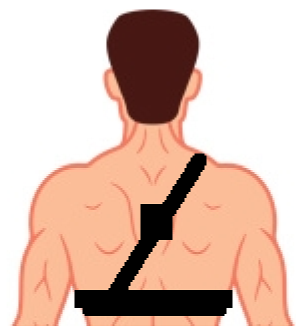
For the supplementation intervention, your child will be randomly assigned to consume one of the following supplements: 1) 500 ml of Gatorade or 2) 500 ml of water mixed with MIO flavored water. Your child will be consuming the same liquid at halftime during all games of the first weekend, with the opposite beverage consumed during friendly matches on a subsequent weekend. Gatorade powder consists of water, sucrose (table sugar), dextrose, citric acid, natural flavor, sodium chloride (table salt), sodium citrate, monopotassium phosphate, and flavoring/coloring ingredients. MIO liquid water enhancer ingredients include: Water, Maleic Acid, Propylene Glycol, Citric Acid, Contains Less Than 2% of:, Natural Flavor, Sucralose, Acesulfame Potassium, Potassium Citrate, Red 40, Yellow 5, Blue 1 Lake (CI 42090), Potassium Sorbate. A research assistant will provide the supplementation to your child during half time break of each game. Your child will be asked to meet the research assistant in the bench where the team meets for the half time talk, and ingest the drink in front of the research assistant within 10 minutes half time break. Your child will be asked to keep the same liquid diet, i.e. if she wants to ingest Gatorade only during half time, she will be asked to drink Gatorade in the next games. Both groups will be allowed to ingest water ad libitum during half time as well, and participants will be instructed to keep the same diet during both weekends.

**Food Record:** Each participant will be asked to keep food to maintain consistency in diet. Participants will need to provide a three day food record (two week days and a weekend day) during the weekend prior the games, and on Friday, Saturday and Sunday of each weekend when the games will be played. At the beginning of the study, participants will be educated on how to use the myfitnesspal app. All subjects will be instructed to log food records into a smartphone App ("MyFitnessPal"), and will share their food record with the principal investigator of the study. The purpose of these food records is to ensure that all participants consume the same diet during both weekends (including any liquid as caffeine or carbohydrate drinks), and no major changes in the diet occur during the time of the study. Principal investigator will be looking for consistency in macronutrients. If any participant shows major changes in the diet, this participant will be informed on the importance of keeping a normal diet throughout the study.

**Anthropometric measurement**: Three days prior to the weekend of the first game, investigator will assess player's height and weight via stadiometer- Detecto (Webb City MO, USA). Height and weight will be assessed again on the following Monday after the second weekend of games. This information will allow descriptive analysis of participants.

**Exercise Protocol**: Your child will be part of a supplementation or placebo group in the first weekend with the opposite group in the second weekend. All the players will be outfitted with the heart rate GPS (Zephyr bioharness/ Model BH3, Zephyr Technology Corporation, Annapolis, MD, USA) and its receiver and transmitter (1Hz global positioning receiver/transmitter/BT-Q818XT, QStarz, Taipei, Taiwan) 15 minutes before the beginning of the warm up. After the pre-game warm up, the last piece of the equipment will be fitted into the heart rate bands over the upper-thoracic spine between the scapulae, and the bio-module along the midaxillary line on the left side of the body (underneath the jersey- See pictures below). Players will be tracked in real time using a laptop computer, and data collection will start and finish with the referee's whistle. Running performance and game load will be assessed during the first and second half of friendly soccer matches. Absolute running distance, distance covered per minute, distance covered in each of six velocity categories, and game load will be tracked during 2 games on 2 consecutive weekends. Data is going to use only players that played more than 75% of each game for every game (i.e. 60 minutes/30 minutes per half). Game will be played on field measuring between 50-100 yards in width and 100-130 yards in length, using size ball 5, 11v11 match format (10 field players and 1 goalkeeper), and two half of 40 minutes with 10-15 minutes break between halves.





**Questionnaire:**
*POMS:*

Analysis of mood will be performed through the administration of the POMS Questionnaire, which will be administered before and after each game. The POMS consists of 58 words which provides measures of specific mood states as tension, depression, anger, vigor, fatigue and confusion.

*RestQ76:*

General and sport specific stress will be determined by the REST-Q-76 Sport questionnaire following each game. Participants will answer 77 questions, including one warm up question and 76 test questions, based on how they felt over the last 3 days. Questions are answered using a 7 point Likert-type scale and summed according to the REST-Q administration manual to give 19 subscales of stress and recovery (e.g. general stress, social stress, personal accomplishment, sleep quality, etc.).

**Discomforts and Risks:** Risks associated with soccer practice and games are minimal in a healthy population, but include lightheadedness, fainting, muscle soreness, and in rare incidents, cardiovascular complication or death. Risks will be minimized through health questionnaire of each participant. It should be considered the risk of allergies of Gatorade ingredients (dextrose, citric acid, natural flavor, sodium chloride, sodium citrate, monopotassium phosphate, and flavoring/coloring ingredients), and MIO liquid water enhancer ingredients (water, maleic acid, propylene glycol, citric acid, contains less than 2% of:, natural flavor, sucralose, acesulfame potassium, potassium citrate, red 40, yellow 5, blue 1 lake (ci 42090), potassium sorbate).

Any individual that has Diabetes Mellitus, history of kidney disease, heat-related illness, history of gastrointestinal or febrile illness within past 24 hours, chronic NSAID (nonsteroidal anti-inflammatory drugs) use, or who report history of frequent cramping or an episode of cramping previously, and/or allergies from any of substance used in the study will not be allowed to participate in the study. Research assistants in the soccer fields are certified in CPR, AED use, and first aid. This will help ensure that trained personal will be on location to address any adverse reaction or event during the study. If an adverse reaction or event occurs, the participant will be immediately taken aside for the research assistant to assess the situation, and they will follow the proper protocol for the specific situation that follows the specified guidelines of the facility. If the adverse reaction or event is critical, 911 will be called.

4. Benefits:
   a. Potential benefits to participants in this research study include an increase in distance covered, number of sprints, improve or maintain soccer-skill performance, and increase glycogen concentration maintaining available of exogenous glucose and sparing glycogen or endogenous store.

   b. Athletes involved in multi day tournaments, showcase, or friendlies could benefit from certain interventions that maximize recovery prior the next match or training.

5. Duration/Time required from the participant: You will be tested a total of 6 times throughout the study. Testing for anthropometric measurement will last 20-45 minutes during practice at training location. Exercise and supplementation protocol will last 160 minutes, where you will be assessed 15 minutes before your usual warm up (which last 45 minutes), game halves will last 40 minutes, and supplementation will be assessed during half time. You will be asked to remove the Zephyr bioharness within 10 minutes after the game. This protocol will be the same for both weekends and for all the games.

6. All data collected, including participant information will be stored in separate files on a password-protected computer of which only the PI, Nadima Skeff, will have access. After 7 years all identifiers and related information will be

deleted/shredded. Confidentiality will be maintained by coding all information with individual identification numbers. The master list will be kept in a locked file cabinet in the PI's office. Only qualified research personnel and Georgia Southern University Institutional Review Board (IRB) will have access to the database containing study information. All study data that are entered into statistical analyses and publication reports will refer to group mean data. No individual or group, other than the research team, will be given information unless specifically requested by the IRB. All primary data sources will be kept in the locked file cabinet located in the PI's office. After the conclusion of the study, once investigators are no longer blinded, participants will receive knowledge of which supplement they consumed on each weekend.

7. Right to Ask Questions: You have the right to ask questions and have those questions answered. If you have questions about this study, please contact the researcher named above or the researcher's faculty advisor, whose contact information is located at the end of the informed consent. For questions concerning your rights as a research participant, contact Georgia Southern University Office of Research Services and Sponsored Programs at 912-478-0843.

8. Compensation: There will be no compensation given to you.

9. Voluntary Participation: You are under no obligation to participate in this research, and may end your participation in this study at any time by notifying the lead researcher listed above of your decision.

10. Penalty: There is no penalty for deciding not to participate in the study; at any time they you may withdraw without penalty or retribution.

11. Because the validity of the results of the study could be affected if the purpose of the study is fully divulged to me prior to my participation, I understand that the purpose of the study cannot be explained to me at this time. I understand that I will have an opportunity to receive a complete explanation of the study's purpose following my participation in the study. Again, the conclusion of the study, once investigators are no longer blinded, participants will receive knowledge of which supplement they consumed on each weekend.

You will be given a copy of this consent form to keep for your records. This project has been reviewed and approved by the GSU Institutional Review Board under tracking number H16405.

Title of Project: The effect of half time sports drink ingestion on subsequent half performance in U16 female soccer players during consecutive matches

If you have any questions or concerns regarding this study at any time, please feel free to contact:

Nadima Skeff, Graduate student at Georgia Southern University in the Department of Health and Kinesiology, 234 Barnard Street, Savannah, GA 31401, (912) 508-5229, ns02542@georgiasouthern.edu.

Dr. Riggs, Associate Professor in the Department of Health and Kinesiology, at (912) 478-7753, P.O. Box 8076 School of Health & Kinesiology, Georgia Southern University, Statesboro, GA 30460, ajriggs@georgiasouthern.edu .

______________________________________ ____________________

Parents Consent Date

______________________________________ ____________________

Participant Signature Date

I, the undersigned, verify that the above informed consent procedure has been followed.

______________________________________ ____________________

Investigator Signature Date