ENERGY INTAKES AND ENERGY EXPENDITURES OF PROFESSIONAL, MALE SOCCER REFEREES

By

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ENERGY INTAKES AND ENERGY

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SOCCER REFEREES

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Title of Study: ENERGY INTAKES AND ENERGY EXPENDITURES OF PROFESSIONAL, MALE SOCCER REFEREES

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Abstract:

Objective: The purpose of this study is to explore if professional, male soccer referees meet their energy intake recommendations based upon energy prediction equations. The secondary purpose of the study is to determine if there are comparisons between anthropometric data and their energy intake, energy expenditure, and distance traveled during a game.

Methods: Thirteen male soccer referees (aged 24-47) refereeing for Major League Soccer (MLS) completed the study. Information was provided about their age, height, weight, and body fat percentage; and from that information, their BMI and fat free mass were determined. The referees kept a 4-day food diary to determine energy intake. Their energy expenditure (kcals) and distance traveled (km) were recorded through GPS watch and heart rate monitor during a professional game in which the referee was the center/main referee. The energy consumption was analyzed with SuperTracker to determine energy intake. Energy needs were predicted by applying their age, height, weight, and fat free mass to the Harris-Benedict, Mifflin St. Jeor, and Cunningham metabolic equations.

Results: The average kilocalories consumed by the referees during the four day period was approximately 1887 ± 427.5. This was significantly less than each metabolic equations predicted the referees would need for their activity level. The results found no association between kilocalories consumed, energy expenditure, and distance traveled when compared to age, BMI, and body fat percentage. This study found that referee's energy intake was significantly lower than predicted energy recommendations from all three metabolic equations with activity factors. At an activity factor of 1.7, the Mifflin St. Jeor predicted energy needs closest to what the referees actually consumed.

Conclusion: This lower energy consumption might have an effect on their performance while refereeing. Their ability to think quickly could be negatively affected by their low energy consumption as well as their recovery time. In the future, an energy consumption recommendation for referees based on their activity level should be developed.

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CHAPTER I

INTRODUCTION

Soccer is one of the most popular sports in the world. It is classified as a high-intensity, intermittent team sport lasting 90 minutes with two 45 minute halves (Briggs, Cockburn, Rumbold, Rae, Stevenson, & Russell, 2015). There are 11 players on the field for each team. The general positions of the players on the field include: a goalkeeper, defenders, midfielders, and forwards. The goalkeeper is the only player on the field allowed to use their hands. Defenders play in front of the goalkeeper, and their primary duty is to stop the other team from scoring. Midfielders are the link between the defense and the forwards. They are considered the most physically fit players on the field because they are expected to run the most during the game. They should be able to play offense and progress onto the opponents side of the field, while also being able to retreat and aid in defense. Forwards, also known as strikers, primary goal is to score goals (Soccer Universe, 2012).

The level of play will determine how many referees are officiating on the field during a game. In high school games, there are three referees. One travels the length of the field and stays within the lines of play; this is the center referee. This referee is the only one to carry a whistle and makes all major calls during the time of play. The center referee will enforce the rules of the game and make calls in order to keep all the players safe. The other two are on opposite sides of the field and cover the sidelines. One assistant referee will cover one half of the field while the other covers the other half. Their jobs are to determine which team cleared the ball out of the lines of play. Whichever team cleared the ball, it is the opposite teams chance to throw the ball back into play. In collegiate through professional games, there is a fourth referee involved. This referee stays on the same side of the field as the teams do. Their primary job is to help with substitution of players on and off of the field. They stand at the half-way line and hold up a lighted sign that displays the player's number that is coming off of the field, as well as the number of the player coming onto the field.

According to Fédération Internationale de Football Association (FIFA), in 2007 there were 265 million soccer players in the world, 270 million when referees are included (Kunz, 2007). Although it is the soccer players themselves that attract the most attention in the world of soccer, referees are of equal importance. Referees require an optimal fitness level so they are able to react to the demands of the game in an effective manner. The demands that are placed upon referees are similar to those of the players. There are high-intensity bursts of activity (sprinting) in combination of low intensity activity (jogging) (Reñón & Collado, 2015). The exercise intensity of a soccer referee can be compared to that of a midfield soccer player; on average, a midfielder will spend less time standing still than defenders or strikers (Bloomfield, Polman, & O'Donoghue, 2007). Midfielders spend 2.1% of the time during a game standing, defenders spend 6.3% of the time standing, and strikers spend 5.3% of the time standing. Midfielders spend 14.6% of the time during a game running, and 6.4% sprinting. Whereas defenders spend 7.6% running and 2.5% sprinting and strikers spend 11.1% running and 5.5% sprinting (Bloomfield et al., 2007).

The sport of soccer involves periods and movements that are considered to be high-intensity activity, mixed with periods of lower intensity exercise activity (Svensson & Drust, 2005). Activities can be considered aerobic and anaerobic. Power, speed, muscle strength, flexibility, and agility are all important to being successful on the soccer field for players and referees alike. Speed is an important component because of the fast paced nature of the game. Often-times, possession of the ball can change between the two teams in rapid succession and if speed is not a strong suit in the athlete, it could produce a poor outcome for that team. Speed endurance is also important because one must be able to maintain a sprinting pace whenever it is necessary throughout the game (Svensson & Drust, 2005). Muscle strength is the amount of force or tension a muscle or muscle group exerts against a resistance at a specified velocity during a maximum voluntary contraction. Muscle strength is related to a muscles ability to perform a certain task efficiently. It helps increase the speed at which an athlete can run, accelerate, and increases jumping abilities (Porcari, Bryant, & Comana, 2015). Muscle strength also helps in the avoidance of injuries. Flexibility is the range of movement that a joint can move (Porcari et al., 2015). It is important in prevention of injury. Stretching becomes important in warming up before and cooling down after physical activity. Each individual has different needs when it comes to stretching and this should be taken into account for each player. Agility is the capability to change direction of the body quickly and efficiently (Svensson & Drust, 2005). Agility requires a combination of strength, speed, balance, and coordination. This is important in soccer because of the fast paced play. The ball moves quickly and a player must be able to quickly change direction of their body while controlling the ball.

Referees are held to the same athletic standards of soccer players. This makes it extremely important that referees have many of the same attributes of power, speed, muscle strength, flexibility, and agility as part of a referee's training regimens. It is important that referees take care of their bodies and understand proper nutrition to fuel their athletic performances. A referee must be at the top of their performance at all times, so it could be argued that their nutrition and training is just as important, if not more important than the players on the field. This paper will examine the energy expended by professional soccer referees during a game as well as looking at energy consumption on game day.

The purpose of this study is to explore if professional soccer referees are meeting their energy intake recommendations based upon energy predication equations, including the

Cunningham, Mifflin-St. Jeor, and Harris-Benedict equations. The secondary purpose of this study is to determine if there are comparisons between anthropometric data such as height, weight, and BMI of the referees and their energy intake, energy expenditure and distanced traveled during a game.

Questions to be Investigated:

Research question #1: Are professional, male soccer referees meeting their energy recommendations based on resting metabolic equations and activity factors?

Research question #2: Is there a relationship between anthropometric data (height, weight, BMI) and energy expenditure?

Research question #3: Is there a relationship between anthropometric data (height, weight, BMI) and energy intake?

Research question #4: Is there a relationship between anthropometric data (height, weight, BMI) distance traveled?

Research question #5: How do resting metabolic equations compare to one another?

Limitations:

Limitation #1: The referees not accurately tracking the energy they consume. Food records will be used to record foods consumed.

Limitation #2: The referees not wearing their GPS watches during a game or training session.

Limitation #3: The wide age range between the referees could affect how much energy is consumed as well as how much energy is expended.

Definitions of Terms Used:

Basal metabolic rate: the daily energy needed to sustain cell metabolism and other physiological life processes during a 24 hour time period (Gerrior, 2006).

Energy availability: dietary energy intake minus the energy expended in the particular metabolic demand of interest (Loucks, Kiens, & Wright, 2011).

Estimated energy requirements: daily requirement for energy consumption based upon calculations that take into account: energy intake, energy expenditure, age, sex, weight, height, and physical activity level (Gerrior, 2006).

Kilocalories: a unit equal to 1000 calories; the heat needed to raise the temperature of 1 kg of water from 0 to 1 degree Celsius (Hargrove, 2006).

Metabolic equivalent: how much energy is being expended during a task (Byrne, Hills, Hunter, Weinsier, & Schutz, 2005).

Total daily energy expenditure: the sum of the energy used to carry out normal physiological processes, activities of daily living, and physical activity/exercise. The value will change based upon gender, age, body size, heredity, as well as the duration, frequency, and intensity of the physical activity/exercise (Rodriguez, DiMarco, & Langley, 2009).

Total daily energy intake: the sum of energy consumed from foods, fluids, and supplemental products (Rodriguez et al., 2009).

Abbreviations:

BMR: Basal metabolic rate

FFM: Fat free mass

MET: Metabolic equivalent

PRO: Professional Referee Organization

RMR: Resting metabolic rate

TDEE: Total daily energy expenditure

CHAPTER II

REVIEW OF LITERATURE

Energy Consumption in Soccer Players

The energy expenditure of soccer players are different based upon their age, gender, and the position played. In a study by Briggs et al. (2015), ten male players ages 15.4 ± 0.3 years were used to determine the energy intake and expenditure of adolescent soccer players. During the course of a week, the players recorded their dietary intakes via food journals. It was found that, on average, they weighed 57.8 ± 8 kg and consumed an average 86 ± 10 of g/day of protein, 318 ± 24 g/day of carbohydrate, and 70 ± 7 g/day of fat. On game days, there was a decrease in the consumption of all three macronutrients. And on rest days, there was an increase from the average consumption in fats and protein, as well as a marketed decrease in the consumption of carbohydrate (348 g/day to 281 ± 51 g/day). The average amount of kilocalories consumed on a daily basis was 2245 ± 321 kcal (Briggs et al., 2015).

Another study had ten male soccer players, ages 16-19 years old record their dietary intake for a week. On average, they weighed 67.5 ± 2 kg. Their energy consumptions included: 114 ± 8 g/day of protein 393 ± 18 g/day of carbohydrate, and 100 ± 9 g/day of fat (Russell & Penncok, 2011). The average amount of kilocalories consumed was 2831 ± 164 kcal. The differences between the consumptions can be contributed to the increase in size between the two study groups. When there is an increase in size, there is an increase in energy intake in order to provide enough energy for activities of daily living, as well as fueling extra activities (Russell & Penncok, 2011).

Physical Demands of Soccer

The physical demands of soccer can include fighting for possession of the ball, running off the ball, dribbling, tackling, counter attacking, overlapping, jumping to head the ball and long tactical kicks, all of this leads to a high level of fitness needed to be an effective player (Njororai, 2012). A high level of aerobic fitness is also needed in order to effectively play 90 minutes of a game. Game activities can include short-duration high speed runs, jumps, trots, low speed running and walks (Coelho et al, 2010).

Physical Demands Placed on Soccer Referees

Metabolic equivalent (MET) describes how much energy is being expended during a task. A definition of MET is the quantity of oxygen that is consumed by the body and 1 MET is equal to 3.5 ml oxygen/kg/min (Byrne, Hills, Hunter, Weinsier, &Schutz, 2005). Resting metabolic rate is considered to be at 1 MET, when the body is sitting quietly and consuming approximately 3.5 ml oxygen/kg/min. Light energy expenditure is considered <3.0 METs, and examples include standing, sitting, and walking slowly. Moderate energy expenditure is considered to be 3-6 METs, and examples include walking briskly, light effort bicycling (10-12 mph), or tennis. And vigorous energy expenditure is considered >6.0 METs. Examples include jogging or running, bicycling fast (>14 mph), and competitive soccer (CDC, 2015). On average, during a soccer game, referees will expend approximately 5 METs, and this is predominantly through aerobic energy. Based upon research done, 67% of game time was equal to or lower than 3.8 METs and 33% of game time was higher than 9.8 METs (Inacio da Silva, Fernandes, & Fernandez, 2008).

During a soccer game, referees can travel between 5.25- 8.5 miles, depending upon the level of play (Cerqueira, Inacio da Silva, & Bouzas Marins, 2011; Inacio da Silva et al., 2008; Stolen, Chamari, Castagna, & Wisloff, 2005). There are many different movements that can contribute to the distance traveled by a referee. Some of these movements include: walking, trotting, jogging, running, sprinting, and backwards running (Inacio da Silva et al., 2008). The amount of movements that a referee will do during a game depends upon how much the ball moves throughout the game. Therefore, if the ball moves less, the referee will move less, and if the ball moves more, the referee will move more. The ratio of the different types of movements that are produced will also depend upon the speed of the ball. When adding up the total time of walking, trotting, and backwards running, a referee could spend 60-90% of their time during a game performing these motions (Cerqueira et al, 2011). Higher intensity movements such as moving at speeds of >15-18 km/hour could occur up to16-17% during the course of a 90 minute game, and distances performed at a sprinting pace range from 0.5-12% of total game time (Stolen et al., 2005). For example, in 1268 different activities performed in a 90 minute game, 588 were low intensity activities such as being stopped, walking or trotting. And 161 were high intensity activities such as running and sprinting (Cerqueira et al., 2011).

Testing for Referees

In order to become a referee at a professional level, there are several different physical tests that must be completed. In 2006, FIFA established new tests for the referees. These tests included 20 x 150 meter sprints and 6 x 40 meter sprints. The test requiring 6 x 40 meter sprints measures the average running speed during repeated fast runs over a 40 meter distance. The referee has 6.4 seconds to run each of the 40 meters, with 90 seconds of recovery between each sprint. If a trial is failed, the referee is given another opportunity to retry that sprint. If he fails two trials, the test has been failed (FIFA, 2015). The test requiring 20 x 150 meter sprints is performed in order to test the capacity to perform repeated high-intensity runs. The referees have

30 seconds to cover 150 meters, then 40 seconds to cover 50 meters at a slower (walking) pace (FIFA, 2015).

Energy Expenditure of Soccer Referees

A study done by Inacio da Silva et al. (2008) looked at the energy expenditure of soccer referees during games. The mean age of the group was 38.9 ± 3.8 years. Weight was 86.1 ±7.1 kg and height was 1.80 ± 0.7 meters. This made the average body mass index of 26.5 ± 0.6 kg·m^2. The study followed the referees in 29 different games during the 2005 and 2006 Parana Championship of Professional soccer. Each of the games were video recorded. Standing, walking, jogging, running, sprinting, and backwards running were monitored. After each game, the frequency at which each of the movements were performed were recorded. The average distance covered for each game was 9155.5 ± 70.3 m or 9.155 ± 0.07 km, with the range being 8411-9765 m or 8.411-9.765 km. Time spent in each activity was also recorded and the averages for each were found, and broken down as the following (minutes.seconds): sprinting- 0.24 ± .03, running- 5.20 ± :38, jogging- 17.26 ± .7, backward running- 5.46 ± .27, walking- 47.06 ± .74, standing- 13.59 ± .44 (Inacio da Silva et al, 2008). The results also provided the breakdown of the average distance traveled in each movement: 4591.9 ± 73.4 m walking, 2577.2 ± 127.2 m jogging, 1010.9 ± 74.6 m running, 122.7 ± 19.3 m sprinting, and 852.6 ± 48.7 m backward running. This breakdown leads to 52% of the time was spent walking, 19% spent jogging, and 15% standing.

The average total energy expenditure for the games was 734 ± 11.9 kcal. The average breakdown for kilocalories burned (based upon the above results) during each activity were: sprinting- 11.07 kcal, running- 94.68 kcal, jogging- 256.25 kcal, backwards running- 85.57 kcal, walking- 266.05 kcal, and standing- 21.08 kcal (Inacio da Silva et al., 2008). Together, walking and jogging were 71% of the total energy expenditure during a game, and running and sprinting were 14% of total energy expenditure.

Energy Availability

Energy availability is the amount of energy that can be used to perform other functions and is defined as the dietary energy intake minus the energy expended during exercise (Loucks et al., 2011; Rodriguez et al., 2009). It is thought that when a certain level of reduction in energy intake is reached, impairments of metabolic, hormonal, and reproductive function occur. Once energy availability is lower than 30 kcal/kg body weight, damage is seen. When energy is limited, fat and lean tissue will be used for energy in the body. This loss of lean tissue results in reduced strength and endurance. Other damage that can occur includes: compromised immune system and endocrine and musculoskeletal function (Rodriguez et al., 2009). To determine the amount of available energy, the equation is: (energy intake-energy needed for training)/lean body mass (kg). This provides energy availability in kcal/kg lean body mass.

Energy balance occurs when the energy intake (being the sum of energy from foods, fluids, and supplements) equals energy expenditure or the sum of the energy expended as basal metabolic rate, thermic effect of food, and thermic effect of activity (Rodriguez et al., 2009). The thermic effect of activity is the energy that is expended in planned physical activity as well as non-exercise activity thermogenesis. Persistent negative energy balance can lead to weight loss and disruption of normal physiological processes that can affect the performance of the athlete. Positive energy balance will lead to weight gain, and for some athletes this is not their goal. The more energy that is used during activity, the more energy that will need to be consumed in order to maintain energy balance.

Nutrition for Soccer Referees

The nutritional needs of soccer referees are comparable to that of midfield players (Teixeria, Goncalves, Meneses, and Moreira 2014). That being said, an adequate dietary intake is required to sustain not only daily activities, but also training regiments as well as to have energy and be mentally alert during games. There is a lack of nutrition guidance for referees, but it has been advised to follow the same information as the players: 1.2-1.7 g/kg of protein, 5-12 g/kg of carbohydrate and 20-35% from fat (Teixeira et al., 2014). There is some evidence that states the calorie-consumption will remain the same on different days (i.e., game days, rest days, training days, etc.) as well as other evidence that states caloric consumption will change on different days. (Reñón & Collado, 2015).

Other data provides the information that the food, energy and macronutrient consumption changes based on the day (Teixeria et al, 2014). In a study with 23 professional soccer referees, their intakes of carbohydrates, proteins, and fats were self-recorded for seven days. Their average daily energy intakes were also calculated. The average daily energy intake was 2819 ± 279 kcal. For the macronutrients, the average carbohydrate intake was 4.1 ± 0.8 g·kg, the average protein intake was 1.7 ± 0.2 g·kg, and the average fat intake was 1.4 ± 0.2 g·kg. These represented 44.4 ± 4.4% carbohydrates, 18.4 ± 1.5% protein, and 34.6 ± 4.1% fat for total daily consumption. Compared to recommendations, they fell short in carbohydrate consumption (with the lower end of consumption being 5 g·kg). For their protein intake, they were at the upper range at 1.7 g·kg. Fat consumption was also at the higher end of the range at 34.6% with 35% being the upper percentage. Either way, it has been found that referees do not consume an ample amount of macronutrients that are reported to be necessary for supporting physical demands. This supports the conclusion that referees could benefit from dietary counseling in order to maximize their performance (Teixeria et al, 2014).

Assessment of Energy Consumption

Energy intake is the energy consumed through food that provides energy for the body to go through basic physiological functions (Livingstone & Black, 2003). The nutrients consumed aid in growth, metabolism and recovery. For athletes, it is important to ensure that there is enough energy consumption to not only provide energy for daily activities, but also to providing extra energy for the training (International Association of Athletics Federations, 2004). There are many different methods to determine energy intake; the three most popular methods are dietary recall, food record, and food frequency questionnaires.

Dietary recalls can be used for a 24-hour period to a three day period of time, or longer. In a three day period, the goal is to include two week days, and one weekend day. The objective is for an athlete to consult with a dietitian and discuss with them what and how much the athlete ate over the course of the time period specified. Because a single 24 hour period only encompasses one day of eating, dietary recalls are not the most accurate at estimating a long term energy intake (Yunsheng et al., 2009). It can still be a good indicator of what a general day of energy consumption may look like for the athlete.

Food records require the athlete to fill out what and how much they eat for a certain amount of time (Willett, 2013). The time-frame for this can be as long as is needed depending upon the reason the food record is being kept in the first place; but three days tend to be the length used. There are different ways food records can be kept including: writing what was eaten in a journal, tracking on a website, or using an application on a phone.

Food frequency questionnaires help determine how often an athlete eats certain foods (Willett, 2013). Questions that can be asked range from: “how often do you eat this food in a week?” to “how often do you eat this food in a year?” The types of foods that are suggested can include: fruits, vegetables, poultry, pork, beef, fish/seafood, dairy, eggs, sweets, and coffee/tea. The options that can be chosen for how frequently foods are consumed can include: “never”, “less than 1 time per week”, “1-3 times per week”, “more than 4 times per week”, “once per month” or “once every three months”. This can be done by the athlete individually or it can be conducted by the practitioner working with them.

There can be some limitations involved in recorded energy consumption in athletes. This can include: not being honest about how much was consumed, not being honest about what was consumed, not knowing the portions of what was consumed, forgetting to track what was eaten, or adding foods that weren't actually eaten to the list.

Estimating Overall Energy Requirements for Athletes

Energy needs for every athlete will be different not only based upon the sport they play, but also their body size, energy cost of training (volume, frequency, and intensity of their workouts), and any requirements in growth or changes in physique (International Association of Athletics Federations, 2004). Their needs may also vary throughout the year based upon the training phase they are in. Because the needs are different for each individual athlete, there is no general recommendation for athletes. However, there are recommendations for macronutrients that should be achieved on a daily basis. Enough energy is also needed in order to maintain lean body tissue so that it will not be used as energy.

There is a perceived link between higher protein intake and gain of muscle protein, although this has not been supported with scientific evidence (International Association of Athletics Federations, 2004). It is important for all kinds of athletes (strength and endurance) to consume enough protein to aid in protein synthesis. The timing of the consumption of protein may be more important than the amount of protein consumed. If protein is consumed before and after a resistance workout, there is an enhancement protein synthesis. The recommended amount of protein for athletes is 1.2-1.7 g/kg of body mass per day (Rodriguez et al., 2009). This recommendation should be attained through diet alone without the aid of protein or amino acid supplements. In order to maintain body weight, it is necessary for athletes to consume enough protein.

There has been a suggestion of 6-10 g/kg body mass of carbohydrate for athletes. (Rodriguez et al., 2009). It is generally expressed as a percentage of the total energy consumed. This percentage can be between 50-70% of daily energy consumption. Carbohydrates are also generally increased in preparation for events such as a race or a game. Carbohydrate loading can occur three days out from a competition, and greater than 10 g/kg body mass may be consumed in the time before the competition.

Fat intake should be between 20-35% of total daily kilocalories (Rodriguez et al., 2009). It has been suggested that athletes should consume more mono- and polyunsaturated sources. Consuming less than 20% of total daily intake from fat does not benefit performance, and a high fat diet is also not recommended. Athletes may think that fat is bad for them to consume, but in reality, fat is important not only as a source of energy, but also because of fat-soluble vitamins and essential fatty acids.

As for soccer referees, there is little research that supports a universal recommendation for their overall energy requirements. Research has suggested that they will travel the same distance as a midfielder, but does not specify that they need the same energy intake as midfielders. Until there is a better recommendation in place, referees will need to refer to metabolic equations with physical activity factors to determine their overall energy needs. And for the breakdown of macronutrients, they can follow a general pattern of athletes, such as the one mentioned above.

Resting Metabolic Rate

Total daily energy expenditure or TDEE is the amount of calories the body burns throughout the day. Resting metabolic rate (RMR) is the largest component of a person's daily energy budget, meaning the largest part (60-75%) of TDEE (Speakman & Selman, 2003). It has been found that increases in physical activity can increase RMR (Westerterp, 2013). A single training event or long term training can increase RMR. Metabolic processes in the body need energy. These processes involve building up and breaking down tissues. The rate at which these processes occur are measured in kilocalories per unit of time, and is given at a rate of kilocalories per day. Resting metabolic rate can be determine through direct or indirect calorimetry.

The best way or "gold standard" to determine an individual's energy needs is through direct calorimetry (Kaiyala, 2014). Direct calorimetry measures the heat that is released from the body, which in turn determines the energy needs of an individual. This method is often done in a laboratory or clinical setting, takes the proper machinery, proper training of the technician, time, and money.

Indirect calorimetry also measures the energy needs of the body, but it is a lot quicker and easier to do than direct calorimetry. There are equations that can be used to determine RMR. The Harris Benedict equation is one example of an equation that provides an estimate of the kilocalories that the body uses in a day based upon if a person were to be still and in a post absorptive state (Haaf & Weijs, 2014). Essentially, the equations use anthropomorphic measurements and put them into a regression equation (Livingstone & Kohlstadt, 2005). The equations are:

Male: 13.75 x weight (kg) + 500.33 x height (m) – 6.76 x age (years) + 66.47

Female: 9.56 x weight (kg) + 184.96 x height (m) – 6.74.68 6 x age (years) + 655.10

Another equation that can be used is the Mifflin-St Jeor equation (Haaf, T.T. & Weijs, P.J.M., 2014). This equation also provides an estimate of the kilocalories that the body uses in a day. The equations are:

Male: 9.99 x weight (kg) + 625 x height (m) – 4.92 x age (years) + 5

Female: 9.99 x weight (kg) + 625 x height (m) – 4.92 x age (years) – 161

One other equation that is more often used in athletes is the Cunningham equation (Haaf & Weijs, 2014). The Cunningham equation takes fat free mass (FFM) into account, rather than looking at the height, weight, age, or gender of the individual. The Cunningham equation is:

$$22 \times \text{FFM (kg)} + 500$$

There has been discussion about which equation provides the most accurate information for resting energy expenditure. Based on different research, it has been shown that different equations will turn out differently based upon the population that is being tested on. One example, when comparing the Harris-Benedict and Mifflin equations, both were similar to machine provided resting metabolic rates (Hasson, Howe, Jones, & Freedson, 2011). But when they were stratified by different categories such as sex, BMI, age, and race differences were seen. The Harris-Benedict equation over-predicted resting metabolic rate in 18-29 year olds. And the Mifflin underestimated needs for normal weight individuals. Another study done in 2008 by Weijs determined that the most accurate and precise equation for adults in America was the Mifflin-St. Jeor equation (Weijs, 2008). The adults in this study were 18-65 years old, and had a BMI of 25-40. Also, when looking at adults ages 18-25 that are considered to be healthy weight, the Mifflin equation showed to have the most accurate resting metabolic rate (Rao, Wu, Liang, Wang, & Hu, 2012)

When comparing athletes to non-athletes, the Cunningham equation was the most accurate when testing the athletes (Kim, Kim, Kim, Park, & Kim, 2015). The Cunningham equation overestimated resting metabolic rates of non-athletes. It was also stated that the Harris-Benedict formula either over or underestimated needs for the non-athletes.

Based on the research that has been presented above, the equation that is expected to best represent the needs of the referees will be the Mifflin St. Jeor equation. This is because this equation has been shown to be the most accurate and precise equation for adults ages 18-65

(Weijs, 2008; Roa et al., 2012). Although the referees are comparable to athletes, the Cunningham equation may overestimate the needs of the referees, and the Harris-Benedict may underestimate.

Physical Activity Factors Used to Estimate Energy Requirements

Another part of estimated energy requirements involves physical activity level in the form of a physical activity factors. This factor gives information about the duration and the intensity of the activity of a person for a 24-hour time period (Gerrior, 2006). When using an activity factor, the above equations are used to determine resting metabolic rate, and then those values are multiplied by the activity factor to determine the energy needs for a given day.

Physical activity factors are given in a range (Rodriguez et al., 2009). Sedentary, considered just doing activities of daily living such as getting dressed, household chores, or walking to the bus, is 1.0-1.39. Low activity is 1.4-1.59, and includes activities of daily living and 30-60 minutes of moderate activity per day. An example of moderate activity is walking at 5-7 km/h. Active includes activities of daily living and 60 minutes of moderate activity throughout the day, and is ranged from 1.6-1.89. Very active includes activities of daily living plus 60 minutes of moderate and 60 minutes of vigorous activity, or 120 minutes of moderate activity, is ranged from 1.9-2.5.

According to the Academy of Nutrition and Dietetics, the physical activity factor for athletes should be 1.8-2.3 (Rodriguez et al., 2009). When determining a physical activity factor for soccer referees, the consideration of how much they move throughout the day must be taken into effect. For most referees, their activity factor would place them into an “active” or “very active” category. Once the referee’s RMR equations have been determined, their activity factors can then be multiplied by that value to get an estimated energy requirement.

Summary

Professional soccer referees are just as important to the game of soccer as the players are. They are the ones that run the game, and make sure that rules are followed and players stay safe throughout the duration of the game. While there has been plenty of research on the energy intake and expenditure of soccer players, there has been little research done on the energy intake and expenditure of referees. More research is needed on the actual energy intake of the referees, as well as what a general recommendation should be for them so they are able to perform at the high levels expected. In turn, the purpose of this study is to determine if professional soccer referees are meeting their energy intake recommendations. The secondary purpose is to determine if there are relationships between anthropometric data (height, weight, BMI) of the referees and their energy intake, energy expenditure and distanced traveled during a game.

CHAPTER III

METHODOLOGY

Research Design and Subject Selection

This descriptive study used a convenience sample of male professional soccer referees. A written approval was obtained from the Professional Referee Organization (PRO) prior to the beginning of the study (Appendix A). Referees were informed about the purpose, nature and details of the study using a participant information sheet (Appendix B; Appendix C). All referees were given the option to participate in the study, and consent was given if they were willing to participate. The study was approved by the Institutional Review Board at Oklahoma State University (Appendix D).

Participants

Twenty five professional, male soccer referees (ages 21-46) were invited to participate in the study. In order to participate, all participants had to be professional, full time, center referees. The participants were informed of the purpose and procedures of the study and consent was needed to participate.

Anthropometric and Background Data

The height, weight, body fat percentage, and age of all the referees was gathered. Body mass index (BMI) was then calculated. The Exercise Scientists that worked with the referees collected the body fat percentage of each referee via skin calibers. Fat free mass was determined from measured body fat percentage. Information on their past activities was collected including: how long they have been a referee, if they were physically active outside of training, and if they played sports competitively before they were a referee.

Resting Metabolic Rate

Three equations, Harris-Benedict, Mifflin-St. Jeor, and Cunningham, were used to determine the referees resting metabolic rates; the RMR numbers produced from these equations were also compared to one another. The resting metabolic rates were then multiplied by an activity factor of 1.7 to determine the energy intake needs of each individual referee. These energy recommendations were then compared the reported energy intake of the referees.

Dietary and Activity Collection

The study lasted four days. During the four days, the participants tracked their daily energy intake on a food log (Appendix E), and took pictures of each meal with their cell phones (Appendix F). The participants all wore GPS watches to track their activity and energy expenditure during a game in which they were a center referee. Their activity was uploaded onto a website called Polar Flow Coach (Polar Flow, 2016). The website showed the total distance traveled, the time it took to travel that distance, as well as producing continuous heart rate information. Dietary analysis was completed on SuperTracker part of the USDA website (United States Department of Agriculture, 2016).

Statistical Analysis

Descriptive statistics, including means, standard deviations, and percentages were used to describe the referees. A correlation was conducted between the age, height, weight, body fat percentage, body mass index (BMI), and fat free mass (FFM). Average kilocalories consumed, average kilocalories expended, distance traveled (km), and predictors including age, BMI, and body fat percentage were examined using linear regression. The resting metabolic rates of each referee were determined by the Harris-Benedict, Cunningham, and Mifflin St. Jeor equations. The comparison between the three resting metabolic equations were assessed using within subject ANOVA. The energy requirements determined from the above equations were then multiplied by an activity factor of 1.7; this activity factor was chosen because activity factors of 1.8-2.3 are suggested for athletes (Rodriguez et al., 2009). Within subject ANOVA was conducted to determine if the referees met their energy needs based upon their energy intakes and the recommendations determined by the equations. The level of significance for all statistical tests was set at $p < 0.05$.

CHAPTER IV

FINDINGS

Results

A total of 25 referees were eligible for this study, with 13 volunteering to participate (response rate of 52%). The mean Body Mass Index (BMI) was just over into the "overweight" category (>24.9). The mean body fat percentage is within a healthy "fitness" range (14-17%). The average fat-free mass is within a healthy range (Table 1).

Table 1
Descriptive Statistics

N=13	Mean ± Std. Deviation
Age (yr)	37 ± 6
Height (in)	70.65 ± 2.79
Weight (lb)	181.95 ± 20.71
BMI	25.55 ± 1.6
Body Fat Percentage	14.47 ± 1.57
Fat-free mass (kg)	70.77 ± 8.53
Average kcals consumed (kcal)	1886 ± 427
Energy expenditure (kcal)	1597 ± 439.67
Distance Traveled (km)	9.03 ± 1.13

Correlations between age, height, weight, body fat percentage, body mass index (BMI), and fat free mass (FFM) are shown in Table 2. Age is positively significantly correlated with BMI (p=0.029). Height is significantly correlated with weight (p=<0.001), as well as fat free mass (p=<0.001. Weight is significantly correlated with height (p=<0.001), BMI (p=0.004) and fat free mass (p=<0.001). BMI is significantly correlated with age (p=0.029), weight (p=0.004), and fat free mass (p=0.009). Fat free mass is significantly correlated with height (p=<0.001), weight (p=<0.001), and BMI (p=0.009).

Table 2:
Correlation of Predictors

N= 13	Age (yr)	Height (in)	Weight (lb)	Body Fat %	BMI	FFM (kg)
Age (yr)						
Pearson Correlation		.074	.350	.471	*.603	.257
Sig.	-	.810	.241	.104	.029	.397
Height (in)						
Pearson Correlation			**.892	-.413	.358	**.909
Sig.		-	.000	.161	.230	.000
Weight (lb)						
Pearson Correlation				-.274	**.740	**.988
Sig.			-	.365	.004	.000
Body fat %						
Pearson Correlation					.044	-.418
Sig.				-	.887	.155
BMI						
Pearson Correlation						**.691
Sig.					-	.009
Fat Free Mass (kg)						
Pearson Correlation						
Sig.						-

*. Correlation significant at 0.05 level; **. Correlation significant at 0.01 level; BMI= body mass index; FFM= fat free mass.

Linear regression was conducted for age, BMI, and body fat percentage to explore predictors of the average kilocalories consumed by the referees (Table 3). The R^2 value is 52.5% (p=.384), and was not significant. Thus there is no relationship between average kilocalories consumed and age, BMI, and body fat percentage. Linear regression was also conducted to explore predictors of average energy expenditure of the referees during a professional Major League Soccer game (Table 4). The R^2 value is 37.8% (p=.692), and was not significant. Thus there is no relationship between average energy expenditure and age, BMI, and body fat percentage. Lastly, linear regression was conducted to explore predictors of distance traveled during the same game the referees energy expenditure was measured (Table 5). The R^2 value is 30.8% (p=.323), and was not significant. Thus there was no relationship between distance traveled and age, BMI, and body fat percentage. The “B” in Tables 3-5 indicates the values for the regression equation for predicting the dependent variable from the independent variable. For example, in Table 3, with every year of increased age, the average kilocalories consumed is predicted to increase by 39 ± 29.649 kilocalories. In Table 4, with every unit of increase in BMI, the average energy expenditure is predicted to increase by approximately 32 ± 123.545 kilocalories. In Table 5, with every increased percentage of body fat, the average distance traveled is predicted to decrease by .35 ± .239 km. The “beta” in Tables 3-5 is the standardized coefficient and is used to compare the contribution of each independent variables. The largest beta coefficient in each table marks the strongest contribution to explaining the dependent variable. The larger the beta coefficient, the lower the p-value, and higher significance. In Table 3, the largest contributor to the average kilocalories consumed is body fat percentage. In Table 4, the largest contributor to energy expenditure is age. In Table 5, the largest contributor to distance traveled is body fat percentage.

Table 3:
Regression Analysis of Average Kilocalories Consumed

Variable vs. Average Kilocalories (kcal)	*B*	*SE B*	*β*	*p*
Age (yr)	38.879	29.649	.562	.222
BMI	-149.456	110.445	-.512	.209
Body fat percentage	-153.004	92.933	-.564	.134

Note: R^2= 0.525 (p=0.384).

Table 4:
Regression Analysis of Energy Expenditure

Variable vs. Energy Expenditure (kcal)	*B*	*SE B*	*β*	*p*
Age (yr)	-23.590	33.166	-.332	.495
BMI	32.426	123.545	.108	.799
Body fat percentage	-40.186	103.955	-.144	.708

Note: R^2= 0.378 (p=0.692)

Table 5:
Regression Analysis of Distance Traveled

Variable vs Distance Traveled (km)	*B*	*SE B*	*β*	*p*
Age (yr)	.019	.076	.102	.812
BMI	-.282	.284	-.366	.348
Body fat percentage	-.351	.239	-.490	.177

Note: R^2= 0.308 (p=0.323).

Analysis of Metabolic Equations

The statistics for the metabolic equations without the activity factor are shown below in Table 6. These statistics are looking at the kilocalorie needs of the referees predicted by the metabolic equations, not the amount kilocalories consumed by the referees.

Table 6:
Metabolic Equations

Equation	Mean ± Std. Deviation
HB	1849 ± 155
MSJ	1769 ± 130
CUN	2057 ± 188

HB= Harris-Benedict; MSJ= Mifflin St. Jeor; CUN= Cunningham

Table 7 shows the average kilocalories consumed by the referees and the average recommended kilocalories needed as estimated by metabolic equations with an activity factor of 1.7.

Table 7:
Descriptive Statistics for Metabolic Equations with Activity Factor 1.7

Equation	Mean ± Std. Deviation
Avg kcals	1887 ± 428
HB	3144 ± 263
MSJ	3008 ± 221
CUN	3497 ± 319

Avg kcals: average calories consumed; HB= Harris-Benedict; MSJ= Mifflin St. Jeor; CUN= Cunningham

The difference between the predictive metabolic equations and the difference between the average calories consumed by the referees are shown in Table 8. For example, when looking at the first row, “avg kcals”, when compared to the Harris-Benedict (HB) equation, the average kilocalories consumed is approximately 1257 ± 145.995 kilocalories less than the average prediction of the HB equation. When looking at the Mifflin St. Jeor (MSJ), the average kilocalories consumed is approximately 1121 ± 138.895 kilocalories less than the MSJ equation predicted. When looking at the Cunningham (CUN) equation, the average kilocalories consumed is approximately 1610 ± 152.895 kilocalories less than the CUN equation predicted. All equations, when comparing to the other equations or to the average energy consumption, showed a statistically significant difference.

Table 8:
Comparison of Average Kilocalories consumed and Metabolic Equations

(A) Equation	(B) Equation	Mean Difference (A-B)	Std. Error	Significance
Avg kcals	HB	-1257.083*	145.995	<0.001
	MSJ	-1121.160*	138.895	<0.001
	CUN	-1610.006*	152.895	<0.001
HB	Avg kcals	1257.083*	145.995	<0.001
	MSJ	135.923*	11.851	<0.001
	CUN	-352.923*	26.221	<0.001
MSJ	Avg kcals	1121.160*	138.895	<0.001
	HB	-135.923*	11.851	<0.001
	CUN	-488.846*	33.800	<0.001
CUN	Avg kcal	1610.006*	152.895	<0.001
	HB	352.923*	26.221	<0.001
	MSJ	488.846*	33.800	<0.001

*. The mean difference is significant at the <0.05 level; HB= Harris-Benedict; MSJ= Mifflin St. Jeor; CUN= Cunningham

Table 9 shows the difference in the metabolic equations for predicting the kilocalorie needs for the referees. For example, when looking at the first row, the Harris-Benedict equation is, on average, 80 ± 6.945 kilocalories more than the Mifflin St. Jeor equation (MSJ). The Harris-Benedict equation is also, on average, 207 ± 15.457 kilocalories less than the Cunningham equation (CUN). All three equations predicted statistically significant kilocalorie needs when compared to the other equations. Harris-Benedict predicted significantly different energy needs than both the Mifflin St. Jeor and Cunningham equations; The Mifflin St. Jeor equation predicted significantly different energy needs than the Harris-Benedict and Cunningham; and the Cunningham predicted significantly different energy needs than the Harris-Benedict and Mifflin St. Jeor.

Table 9:
Comparison of Metabolic Equations for predicting kilocalorie needs

(A) Equation	(B) Equation	Mean Difference (A-B)	Std. Error	Significance
HB	MSJ	80.077*	6.945	<0.001
	CUN	-207.692*	15.457	<0.001
MSJ	HB	-80.077*	6.945	<0.001
	CUN	-287.769*	19.864	<0.001
CUN	HB	207.692*	15.457	<0.001
	MSJ	287.769*	19.864	<0.001

*. The mean difference is significant at the <0.05 level. HB= Harris-Benedict; MSJ= Mifflin St. Jeor; CUN= Cunningham.

CHAPTER V

CONCLUSIONS

Discussion

Nutritional requirements for each individual person playing a sport are going to be different depending on the type, intensity, and duration of exercise. In this instance, with soccer, that involves sprinting, running, jogging, walking, turning, and (for the referees) keeping up with the players athleticism. Thus in order to satisfy the high nutritional needs of the referees, it is necessary to estimate the appropriate needs based on activity and develop an adequate plan to meet the needs. An adequate diet will then hopefully positively influence the referee's performance and recovery time.

Surprisingly there is no significant predictor of average kilocalories consumed by the referees. In addition, there is no significant predictor of distance traveled or energy expenditure by the referees. A larger person tends to expend more energy while they are being physically active. This is because they have more weight to move than a leaner person does, and with more weight to move, comes a higher level of energy needed (Westerterp, 2013). A larger person also tends to have a higher energy dense diet (Vernarelli, 2016).

Linear regression analysis (Tables 3-5) was conducted with only three predictors (age, BMI, and body fat percentage) due to a high correlation rate between the other predictors (weight, height, and fat free mass) (Table 2). There is also a positive correlation between fat free mass and height, weight, and BMI. BMI includes height and weight in the equation when determining BMI, so those predictors were left out. Fat free mass was excluded from the regression analyzes because it can be determined through body fat percentage.

The metabolic equations are often used as predictors of energy needs because they are the easiest, quickest, and cheapest way to estimate an individual's energy needs outside of a laboratory setting. The metabolic equations are a way of predicting the needs of the referees, and the results may have been an over or under prediction of what they actually need. Just because they did not meet these high levels of energy needs that the equations predicted, does not mean that there will be any detriment to their health. It means a closer look needs to be taken at the way metabolic rate, energy consumption and energy expenditure was measured.

When calculating the average kilocalories consumed by the referee compared to the metabolic equations with an activity factor of 1.7, all the predictive equations predicted a need for a higher calorie intake than what the referees reported consuming. An activity factor of 1.7 was chosen because activity factors of 1.8-2.3 are suggested for athletes (Rodriguez et al., 2009). Based on the definitions of what "active" and "very active" are, referees easily fall into this category. "Active" includes activities of daily living and 60 minutes of moderate activity throughout the day. "Very active" includes activities of daily living and 60 minutes of moderate and 60 minutes of vigorous activity or 120 minutes of moderate activity (Rodriguez et al., 2009). Often times the referee is not running as much as the soccer players are during a game, which is why the activity factor of 1.7 was used, rather than a number within the range for athletes. All three equations, with activity factors, predicted a higher need for kilocalories than what the referees were actually consuming. These results may indicate that the referees are not consuming enough kilocalories for how active they are at the professional level. This is because the metabolic equations are predicting how much energy they will need for their activity level, and because they are not meeting these needs, they may end up in a negative energy balance. Which can lead to unwanted weight loss and disruption of normal physiological processes (Rodriguez et al., 2009). These referees have an important job to maintain control of the game and to ensure that the players stay safe and follow the rules. They need to be in the best physical shape that they can be to make sure they can keep up with the players to make adequate calls; and if they are in a negative energy balance, they may not be able to make the appropriate calls.

Another portion of this study was looking at the metabolic equations without activity factors to explore a difference in predictive ability of the equations. There was a significant difference between all three equations. The Harris-Benedict and Mifflin St. Jeor were closest to each other, with a difference of approximately 80 kilocalories (with the Harris-Benedict predicting higher needs than the Mifflin St. Jeor). These results are similar to what has been found in other research studies done by Hasson et al., 2011 and Kim et al., 2015. There has been research to show that both the Harris-Benedict and Mifflin St. Jeor equations produce similar results as a metabolic cart would (Hasson et al., 2011). But, much like the result presented in this study, the Harris-Benedict equation may over predict (compared to the Mifflin St. Jeor). And the Mifflin St. Jeor tends to underestimate the needs for normal weight individuals. When using the Cunningham equation, in the present study, the equation predicted 207 more kilocalories than the Harris-Benedict and 287 more kilocalories than the Mifflin St. Jeor equation. This is expected because this equation is best for predicting the needs of athletes, a population who generally needs more kilocalories than the general population (Kim et al., 2015). This equation would also overestimate the needs of non-athletes, which explains why the present study shows the equation predictions to be higher than the Harris-Benedict and the Mifflin St. Jeor equations.

The Cunningham equation may be the most appropriate metabolic equation to predict the energy needs of professional referees because it has been noted that their energy needs are similar to professional players (Reñón & Collado, 2015). The referees are likely to be more active than the general population, and will therefore need to consume more energy than the general population. Using the Cunningham equation will produce a higher energy need than the other two equations. However, based upon the results of this study, the Mifflin St. Jeor predicted energy needs closer to what was actually consumed by the referees (Table 7). The metabolic equations with an activity factor of 1.7 predicted very high energy needs for the referees compared to their actual consumption. That being said, the Mifflin St. Jeor equation may be the best equation to use in practice with this population as it is easier to use because body fat percentage does not have to be determined and age, height, and weight are easy to figure out. Also, because it is the most accurate equation when looking at adults ages 18-65 (Weijs, 2008).

In the present study, the referees average energy consumption was determined from the four days that they recorded their intake. These four days included a game day (in which they were the referee), as well as a day or two of travel and a training day. The referees varied on which days they consumed more kilocalories. Some of the referees consumed more on game days compared to travel days, which may be due to their extra energy expenditure during the game. Whereas others consumed more on travel days than on game days. The actual game day can be so busy with travel and game prep that energy consumption may actually be lower than a travel day. Future research could consider the potential of the referees needing higher calorie consumptions on games days as compared to their travel or training days due to the differences in energy expenditure or visa versa.

Other studies have found some similar results in distance traveled compared to the present study. In a study done by Inacio da Silva et al. (2008), the results found that the referees traveled 9.155 ± 0.07 km during the course of a professional soccer game. Distance traveled ranged from 8.411 to 9.765 km. The results from this study found that the average distance traveled by the referees during a professional soccer game was 9.03 ± 1.13 km and ranged from 6.64 to 11 km. These results show that referees run close to the same distance during a professional game.

Results on energy expenditure from the same study done by Inacio da Silva et al. (2008), found that the referees expended 734 ± 11.9 kilocalories during the course of a professional game in which they were a center referee. The results from the present study found that the average energy expended during a professional game (in which the referee was the center referee) was 1597 kilocalories during a game. The results between the two studies are so different because of the methods used to calculate the energy expenditure. In the study done by Inacio da Silva et al. (2008), the movements of the referees were divided into how long they spent doing each movement. Kilocalories for each movement were estimated and multiplied by how long they spent doing each movement. This may not have been the most accurate method to estimate the energy expenditure of the referee because it is using their movements alone, and an estimation for their kilocalories expended. In the present study, the referees wore heart rate monitors during the game that their energy expenditure was measured. The GPS watches that the referees wore during the game are set to have their height and weight programmed into them; so when they upload their information with their heart rate data, the results for their energy expenditure is not just their heart rate information. It also takes into account how fast and how much they moved (from the GPS watch) and their height and weight as well. This is a more accurate way of collecting energy expenditure than estimating kilocalories based upon time doing a certain movement because it takes into account the referee's heart rate, distance traveled, height, and weight (FirstBeat Technologies Ltd, 2012).

When determining the average kilocalories consumed by the referees in the present study, compared to the average kilocalories consumed by referees in a study done by Teixeira et al. (2014), the difference is large. Teixeira et al. (2014) determine that their referees consumed approximately 2819 kilocalories, on average. The present study estimated the referees consumed nearly 1000 kilocalories less than the Teixeira et al. study. The difference produced between the two studies is likely due to the different nutrition analysis programs used to estimate nutrient intake by the referees. The present study used SuperTracker as part of the United States Department of Agriculture website, and the study done by Teixeira et al. used ESHA Food Processor® 8.0 for Windows. The difference due to inaccuracies from self-reporting food logs by under or over estimating of consumption. Another possibility is because the present study was conducted for 4 days, and the other study was done for 7 days. The length in time could include days with greater calorie consumption.

Strengths

A strength of this study is the use of the heart rate monitors in conjunction with the GPS watches. The heart rate monitors measured the exertion of the referees during the game. By having the referees wear a heart rate monitor, this study was able to more accurately record the energy expenditures of the referees. Another strength is that the data was collected at a variety of venues throughout the four days that their food diaries were done; these include in airports, on airplanes, in locker rooms, restaurants, and at home. This matches how the referees have to live their lives on a regular basis.

Limitations

When working with individuals and having them record their own dietary intake, there will always be limitations with how accurate the consumption data actually is. There is a possibility for under or over reporting the food that was consumed by the referees during the four days. Inaccuracies may also be found in the energy expenditure data of the referees. During the course of a game, a referee may or may not turn off their watch during half time (generally 15 minutes), and they might also include their warm up time while his watch is running. This means that the distance he traveled and kilocalories burned during the warm up and walking to the locker room during half time may be represented in the overall distance traveled and energy expenditure of the referees. This will lead to an inaccurate description of the distance traveled during the game alone.

Conclusions

This study found that male professional soccer referees are not meeting their recommended energy intakes, based on predictive equations. This is worrisome because of the high level of energy needs that the referees have, as well as how high the stakes are during these games to make appropriate calls. If referees continue to not met their energy needs, this could impact their decision making during games, the time it takes them to recover, and it could impact how they referee the game.

The game of soccer is rapidly changing with instant replays, athletes are becoming stronger and faster, and the number of fans continues to grow with every game. The pressure for these referees to be quick on their feet, make correct calls, stay healthy, and prevent injuries continues to increase. With every game, and every season, the referees need to be in the best shape possible, which includes improving their diet and making sure they are consuming enough calories to fuel their bodies to perform the actions of their jobs well.

Future research can expand into macronutrient break down of the referees compared to the macronutrient needs of professional athletes. Future research should also look at the use of an activity factor of 1.5, rather than 1.7 to determine if energy needs are being met at a lower activity level. Another area of interest is the energy consumption and energy expenditure of referees on their training days. Then comparing their energy consumption on game days versus training days. In the future we hope to expand energy recommendations into the specific sport of soccer. There are recommendations for athletes in all types of sports, but there are only estimates for referees. Referees are an important part of the game of soccer, it is only appropriate that they should have recommendations as well.

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APPENDICES

Appendix A: The following is a letter written from the Professional Referee Organization authorizing the use of the information of the referees.

PRO Professional Referee Organization

To Whom It May Concern:

My name is Matt Hawkey and I work for the Professional Referee Organization (PRO) as the Sports Scientist. This Letter is authorization for Dr. Gena Wollenberg and her graduate student Steffany Bixby to use data already gathered from the 2015 PRO season along with a one-time food record collected via pictures. PRO is the sole owner of the data, and thereby is granting Dr. Wollenberg and Steffany the permission to use the data for the sole purpose of analysis for research, presentation of finding at PRO sanctioned conferences, and/or journals. All data will follow proper research protocol that will identify and code individual subjects by number only.

Should you need any further information please feel free to contact me at matt.hawkey@proreferees.come or at 917-297-6602.

Thank you-

Matt Hawkey

Matt Hawkey
Sports Scientist
Professional Referee Organization
917-297-6602
matt.hawkey@proreferees.com

Appendix B: The following is the script that was read to the referees when they were recruited to participate in the study.

"Hello, my name is Steffany Bixby. I am a graduate student at OSU, working towards receiving my Masters of Science in nutrition. For my thesis, I plan to investigate the energy consumption and energy expenditure of professional soccer referees. Specifically, I will be looking at energy consumption and expenditure on rest, travel, training, and match days. I am here to invite you to participate in my study.

If you want to participate, you will be asked to answer a few questions regarding general information and health such as your age, height, weight, and questions regarding your position as a referee. The duration of the study will be 7 days, and will include days that are rest, travel, training, and match days. You will be asked to wear your watches and heart rate monitors throughout the duration of the week that you are being tested. Throughout the duration of the week, you will also be asked to record your food intake through a free app that you'll install on your phone. You will be given a username and password to allow you to log into this app.

If you want to take part, you will need to read the participant information sheet that I will pass around right now. Also, sign up with your name and email address if you want to participate so I can reach you if needed and to provide you with your login information for the food app. My contact information, as well as the contact information for my advisor and Co-PI are on the informed consent from. Feel free to contact us with questions or comments. Those of you who don't want to participate, you are welcome to leave now.

The results of this study will not be linked to you. When you have completed the questions regarding your general information and your health, please return them to me before you leave. If you feel uncomfortable at any time you can remove yourself from the study."

Appendix C: The following is the information sheet that the referees received after they agreed to participate in the study.

"**PROJECT TITLE:**

Energy expenditure and energy expenditures of professional, male soccer referees

INVESTIGATORS:

Steffany Bixby, MS student & Gena Wollenberg, PhD; Department of Nutritional Sciences, Oklahoma State University

PURPOSE:

The purpose of this study is to explore if professional, male soccer referees meet their energy intake recommendations based upon energy prediction equations. The secondary purpose of the study is to determine if there are comparisons between anthropometric data and their energy intake, energy expenditure, and distance traveled during a game.

PROCEDURES:

We are asking you to volunteer to participate in this study because you are a full time professional soccer referee. You must be 18 years of age or older to participate in the study. You sign up for the study using your name and email address. During the study, you will be asked to record the food that you consume for a four day time period that will include Friday-Monday, and a Saturday or Sunday game day. You will also be asked to take pictures of the meals that you consume. Lastly, you will also be asked to upload your game data from the game you were a center referee while you were logging your food information, onto the Polar Flow website

RISK OF PARTICIPATION:

The risk from participating in this study is minimal.

BENEFITS OF PARTICIPATION:

There is little data that has been collected for the recommended energy consumption of professional soccer referees. By participating in this study, we will be able to learn more about how much energy should be consumed by professional soccer referees to support the amount of energy expenditure that is seen throughout different situations. The results of this study will help in forming a general recommendation for energy consumption based upon energy expenditure in professional soccer referees.

CONFIDENTIALITY:

We will protect your confidentiality during the project. No identifiers will be used in this study. Your name will not be linked to your food records from the food application or to your energy expenditure information. Any manuscripts/reports/presentations we prepare from the study will be presented as group data and no individuals will be identified. The OSU Institutional Review Board has the authority to inspect consent records and data files to assure compliance with approved procedures.

Your participation in the study is voluntary. If you feel uncomfortable while reporting any information, you can choose not to answer any question, or to withdraw completely from the study at any time. A decision to withdraw from the study will not result in any consequences.

CONTACTS:

If you have questions about the project, please contact Gena Wollengber at (405) 744-6954 or gena.wollenberg@okstate.edu, or Steffany Bixby at (503) 481-2408 or steffany.bixby@okstate.edu. If you have any questions about your rights as a research participant, you may contact Dr. Shelia Kennison, Institutional Review Board Chair, 219 Cordell North, Oklahoma State University, Stillwater, OK 74078 at (405) 744-3377 or irb@okstate.edu.

PARTICIPANTS RIGHTS

You are voluntarily making a decision whether or not to participate in the research study. Returning the completed page regarding your health indicates your willingness to participate in the study."

Appendix D: The following is the approval from the Institutional Review Board at Oklahoma State University.

Oklahoma State University Institutional Review Board

Date:	Tuesday, November 24, 2015
IRB Application No	HE1571
Proposal Title:	Energy expenditure and consumption of professional soccer referees on rest, travel, training and match days.
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 11/23/2018

Principal Investigator(s):

Steffany Bixby	Gena Wollenberg	Nancy Betts
	1015 E Franklin	301 HS
Stillwater, OK 74078	Stillwater, OK 74075	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms
2. Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of the research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Dawnett Watkins 219 Scott Hall (phone: 405-744-5700, dawnett.watkins@okstate.edu).

Sincerely,

Hugh Crethar, Chair
Institutional Review Board

Appendix E: The following is the food log that the referees filled out. They filled out one for each of the four days of the study.

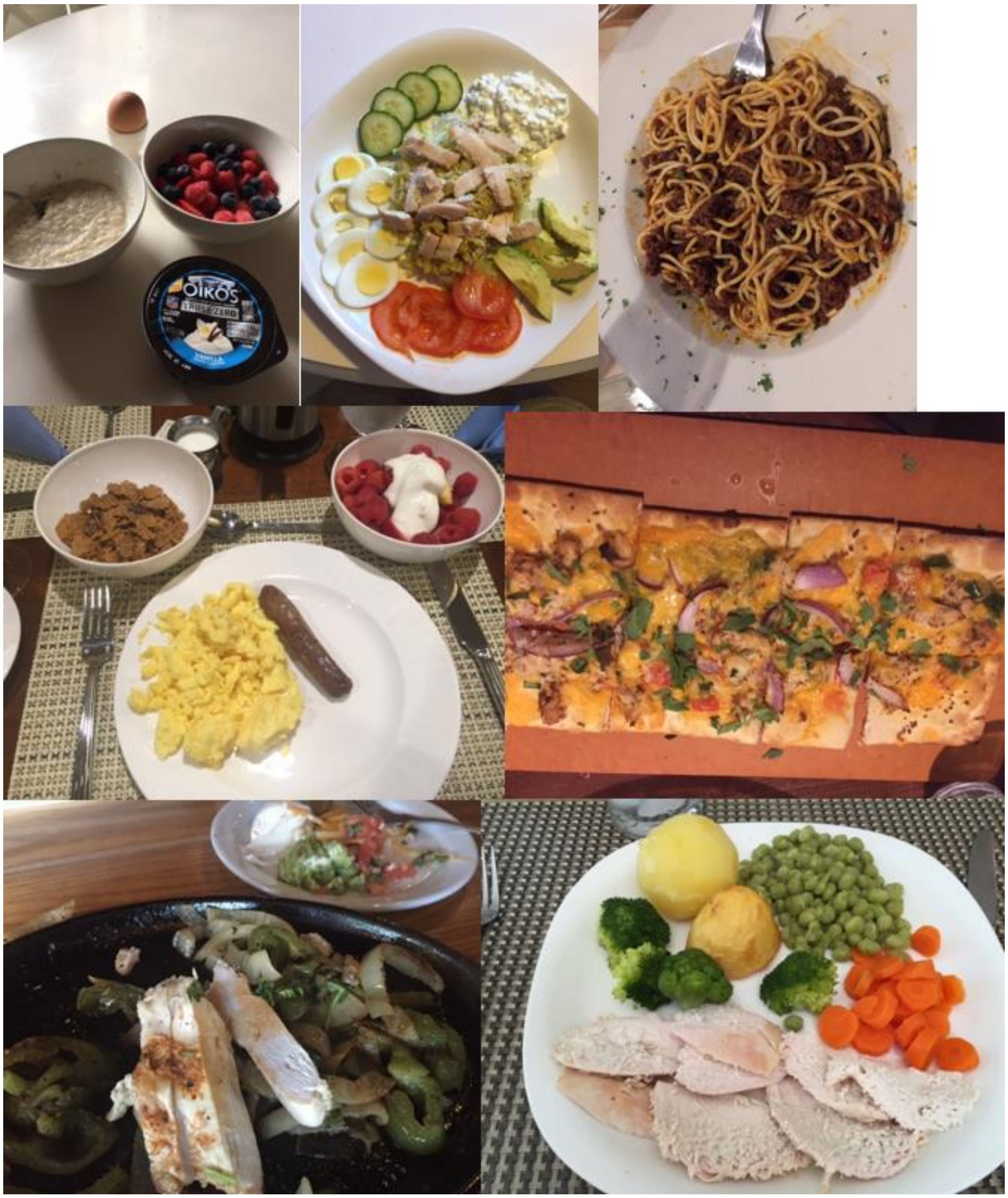
FOOD RECORD- DAY 1

BE THOROUGH

Name: **Day & Date:**

Time of the day	Description of Foods & Beverages	Serving Size	Additional Info

Appendix F: The following are examples of the pictures that were taken during the study by the referees.



VITA

Steffany Bixby

Candidate for the Degree of

Master of Science

Thesis: ENERGY INTAKES AND ENERGY EXPENDITURES OF PROFESSIONAL, MALE SOCCER REFEREES

Major Field: Nutrition

Biographical:

Education:

Completed the requirements for the Master of Science in Nutrition at Oklahoma State University, Stillwater, Oklahoma in May, 2017.

Completed the requirements for the Bachelor of Science in Nutrition and Exercise Science at Oregon State University, Corvallis, Oregon in 2015.

Professional Memberships:

Academy of Nutrition and Dietetics, August 2015- Present

Sports, Cardiovascular, and Wellness Nutrition: a dietetic practice group of AND, August 2015- Present

Professional Experience:

Graduate Teaching Assistant, Oklahoma State University, Department of Nutritional Sciences, August 2015- Present

Graduate Research Assistant, Oklahoma State University, Department of Nutritional Sciences, August 2015- May 2016

Internship, Oklahoma State University, Seretean Wellness Center, January 2016- December 2016

Conferences- Poster Presentations

OkAND, Tulsa, OK; April, 2016
Topic: Energy intakes and energy expenditures of professional, male soccer referees: A Pilot Study

Academy of Nutrition and Dietetics: Sports, Cardiovascular, and Wellness Nutrition (SCAN) Symposium, Portland OR; April, 2016