# SPORTS NUTRITION ATTITUDES, ADEQUACY OF DIET AND ADHERENCE TO SPORTS NUTRITION PRINCIPLES IN NCAA DIVISON 1 FEMALE SOCCER PLAYERS BEFORE AND ONE WEEK AFTER A SPORTS NUTRITION EDUCATION INTERVENTION

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Research is finding that athletes are not following sports nutrition recommendations and principles for their athletic success and potential inadequacies within their diet could be related to poor nutrition knowledge. However, even with an increase in knowledge from the implementation of nutrition education interventions, athletes are still inadequately meeting their recommendations for training, which has been indicated that it could be related to their attitudes about sports nutrition and performance. Therefore, the purpose of this study is to assess sports nutrition attitudes, adequacy of diet and adherence to sports nutrition principles among NCAA Division 1 female soccer players immediately before and one week after a sports nutrition education intervention. The retrospective data included three questionnaires completed by participants: demographic questionnaire, Sports Nutrition Attitudes Assessment (SNAA), and 24-hour food recall. The current study found no significant difference in SNAA score ($t$=1.465, $p$=0.158) and adherence to sports nutrition principles ($t$ = -0.170, $p$=0.867) following a nutrition educational intervention. A significant relationship was discovered between sports nutrition attitude scores and adequacy of diet ($r$=-.442, $p \leq 0.05$) following a

nutrition education intervention, suggesting that the more positive sports nutrition attitude the lower caloric intake the participants consumed.  The findings of the present study suggest nutrition education for athletes needs to be continuous and meant to improve skill and behavior, not just knowledge.

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# CHAPTER I

# INTRODUCTION

Athletic participation by females in the National Collegiate Athletic Association (NCAA) has increased drastically since 1972, and currently accounts for 54% of the intercollegiate teams (Shaw, 1995; Schwarb, 2018). As more and more athletes are beginning to compete in the various divisions of the National Collegiate Athletic Association (NCAA), the level at which these athletes compete continues to escalate (Schwarb, 2018). In order to win games and championships, it is critical for an athlete to to be successful in their athletic performance. Genetic predisposition, state of training, and concept of psychological well-being related to sports can all have the potential to benefit an athlete's performance capabilities (De Moor et al., 2007; Wang et al., 2013; Loos et al., 2015; Peplonska et al., 2016; Centers for Disease Control and Prevention, 1999; Davies, 2016; Bali, 2015; Gee, 2010). As research has continued to grow over the past 90 years (Dunford, 2010), an additional component for athletic performance success if being recognized, nutrition. Nutrition is becoming a recognized as one of the key influencing components of benefiting athletic performance with evidenced-based research opening the eyes of the possibilities food can do (Thomas, Erdman & Burke, 2016).

The Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine have reviewed current research in the field of nutrition related to athletic performance and created a comprehensive position paper on sports nutrition principles and recommendations nutrition professionals should use as guideline for their athletes (Thomas et al., 2016). These guidelines differ from the Dietary Guidelines for Americans because the athletic population require a variation of intake for calories, macronutrients, fluids and potentially micronutrients to support their training demands (Thomas et al., 2016; Dunford & Doyle, 2015; U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015; Burke, 2007). Adequacy in total calories, carbohydrates, protein and hydration status help the body's ability to perform by replenishing muscle glycogen stores and supporting muscle protein synthesis to delay fatigue and decrease the risk of injury that can be associated with fatigue (Manore, Meyer & Thomas, 2009). Despite set sports nutrition recommendations and principles specific for athletes, researchers are finding that some athletes do not adhere to these principles. As a result, this may lead to inadequate dietary intake compared to their body's individual need, which has the potential to negatively affect their athletic success (Martinez Reñon, & Collado, 2015; Ghloum & Haiji, 2011; Alves Coutinho, Melo Porto, & Rocha Pierucci, 2016; Farajian, Kavouras, Yannakaiulia, & Sidossis, 2004; Fox, McDaniel, Breitbach, & Weiss. 2011; Clark, Reed, Crouse & Armstrong, 2003; Valliant, Pittman Emplaincourt, Kieckhaefer Wenzel & Hilson Garner, 2012; Rossi et al., 2017).

With the recognition that many athletes are receiving inadequate nutrition, nutrition professionals have started implementing nutrition education interventions to various age groups competing in different types of athletic competition to help increase the overall knowledge about nutrition related to sports performance (Weeden, Olsen, Batacan, & Peterson, 2014; Rossi et al., 2017; Andrews, Wojcik, Boyd, & Bowers, 2016). There is evidence to support that nutrition education interventions can significantly improve nutrition knowledge scores on various topics of nutrition (Rossi et al., 2017; Weeden et al., 2014). However, even with successfully completing a sports nutrition education intervention, athletes are still consuming inadequate calories and macronutrients for their individualized training needs (Martinez Reñon, & Collado, 2015; Farajian et al., 2004; Fox, et al., 2011; Clark et al., 2003; Valliant et al., 2012; Rossi et al., 2017). Findings indicate that attitude is a potential factor that can influence an athlete's behavior in adhering to sports nutrition principles and consuming an adequate diet (Stickler, Thomas & Morse, 2018; Dwyer et al., 2012; Mohd Elias, Abu Saad, Taib, & Jamil, 2018).

## Statement of the Problem

Contradicting sports nutrition attitudes may influence collegiate athlete's behaviors of adherence to sports nutrition principles and adequacy of their diet. Research supports the ability for an athlete to have an increase in nutrition knowledge and motivation to fuel for performance and implementation of sports-nutrition specific dietary practices following a nutrition education (Alaunyte, Perry, & Aubrey, 2015; Rossi et al., 2017; Mohd Elias et al., 2018; Patton-Lopez, Manore, Meng, Wong, & Branscum, 2018). An increase in sports nutrition knowledge has found to influence a more positive sports nutrition attitude related to quality of diet and its ability to aid in improved athletic performance in collegiate athletes (Rash, Malinauskas, Duffin, Barber-Heidal & Overton, 2008; Hornstrom, Friesen, Ellery & Pike, 2011).

However, even with the implementation of group and one-on-one nutrition education interventions that last for various weeks, and the increase of knowledge and positive attitudes around fueling for performance, athletes are missing the mark when it comes to their behaviors. When compared to dietary recommendations and sports nutrition principles, athletes continue to consume inadequate or disproportioned calories and macronutrients in relation to their training and competition (Mohd Elias, et al., 2018; Valliant et al., 2012). Interventions have shown improvements, but are still are not meeting individual's needs. There is a missing piece as to why these educational interventions are not generating adequacy and adherence. Investigating athlete's sports nutrition attitudes can help nutrition professionals better understand how to improve an athlete's adequacy of diet and adherence to sports nutrition principles.

## Purpose Statement

The purpose of this study is to assess sports nutrition attitudes, adequacy of diet and adherence to sports nutrition principles among NCAA Division 1 female soccer players immediately before and one week after a sports nutrition education intervention.

## Research Hypotheses

$H_1$: Participants will have a improved sports nutrition attitude scores one week after a sports nutrition education intervention compared to sports nutrition attitude scores immediately before a sports nutrition education intervention.

$H_0$: Participants will have no difference in sports nutrition attitude scores one week after a sports nutrition education intervention compared to sports nutrition attitude scores immediately before a sports nutrition education intervention.

$H_2$: Participants will have a improved adherence to sports nutrition principle scores one week after a sports nutrition education intervention compared to adherence to sports nutrition principle scores immediately before a sports nutrition education intervention.

$H_0$: Participants will have no difference in adherence to sports nutrition principle scores one week after a sports nutrition education intervention compared to adherence to sports nutrition principle scores immediately before a sports nutrition education intervention.

$H_3$: There will be a significant relationship detected between sports nutrition attitude scores and adequacy of diet one week after a sports nutrition education intervention.

$H_0$: There will be no significant relationship detected between sports nutrition attitude scores and adequacy of diet one week after a sports nutrition education intervention.

## Operational Definitions

Sports nutrition attitude (SNA): Sports nutrition attitude is measured using a Sports Nutrition Attitudes Assessment (SNAA) on a Likert type scale of 1-5 assessing how the athlete perceives sports nutrition principles related to their athletic performance success.

Adequacy of diet: The diet of an individual athlete meets their recommended total calories of 37-40 kcals/kilogram of body weight per day when compared to their analyzed 24-hour food recall total calories for pre and post nutrition education intervention.

Adherence to sports nutrition principles: Adherence to sports nutrition principles is measured by analyzing 24-hour food recall questionnaires pre and post nutrition education intervention, and comparing them to the following sports nutrition principles criteria; no meal skipping, eating every 3-4 hours, eating less than two hours pre and post training/competition and hydration consumption greater than or equal to 2.7 liters of fluids, providing a +1 score for each criteria met and a 0 for each criteria not met, to compute a total score from 0-5.

NCAA Division 1 female soccer player:  A collegiate female student between ages 18 to 21-year-old that identifies as a freshman, sophomore, junior or senior enrolled in an undergraduate institution that is participating in a NCAA regulated athletic soccer program.

# Chapter II

# REVIEW OF THE LITERATURE

## NCAA History

Intercollegiate competitions began when Harvard and Yale rowing teams competed against one another back in 1852 (Hums & MacLean, 2004; Weight & Zullo, 2015**).** Prior to this, universities did not have competitive sports teams that competed against other universities, the focus was organized student athletic activities competing against individuals within that distinct university setting (Hums & MacLean, 2004). After 1852, the popularity of intercollegiate athletics became an influence on a universities overall academic setting. By 1906 the National Collegiate Athletic Association (NCAA) was born and continued to grow with the addition of sports and increase in available participants (Bass, Schaeperko & Bunds, 2015). During the 1970s and 1980s, monumental changes began taking place for the NCAA. The NCAA took initiative in dividing into three separate divisions that we are familiar with today, Division 1, Division 2, and Division 3 (Yost, 2010).

## Women in Athletics and Title IX

College athletics became completely changed in 1972 with the addition to Title IX to the Education Amendment. Title IX was the key component in allowing women to now participate in athletics competitively because of Title IX mandating inclusions of all individuals to have the opportunity to participate in educational and institutional programs if that institution was receiving and federal funding (Shaw, 1995). In the 2017-

2018 academic year, 494,922 students competed amongst all three athletic divisions (Schwarb, 2018). More than 19,000 intercollegiate teams make up the NCAA organization, in which 54% of the intercollegiate teams are female athletes (Schwarb, 2018). The NCAA has more females than males competing in an NCAA championship sport, with 10,586 teams that competing in a NCAA championship sport were women's teams (Schwarb, 2018).

## Factors Affecting Sports Performance

Different influences in an individual can affect their sports performance and overall capability to perform at a higher capacity than other athletes. Factors of genetic predisposition, state of training, and sports psychology components all play into athletic success.

### Genetic Predisposition

Performance, although requires adequate components of nutrients to aid in the demands of training and athletic success, nutrition is only one factor that can play a role in an athlete's ability to perform at an elite level. Uncontrolled factors such as genetics can hinder or help in an athlete's ability to perform above other individuals. Sixty-six percent of athletic capabilities can be contributed to heredity in genetic factors (De Moor et al., 2007). These genetic factors are known as polymorphisms that are specific to each individual and are linked to phenotypic characteristics, or physical characteristics that can influence the abilities and performance of athletes (Wang et al., 2013; Loos et al., 2015). Peplonska et al., (2017) investigated genetic variants and the association with athletic performance and found certain alleles may have a positive association in prediction of athletic performance, and further can identify what aspect of athletic performance it can contribute to such as power and endurance. Interestingly, genes have the potential to indicate whether an individual will have poor athletic abilities as well. Certain alleles may indicate a negative association in predicting athletic performance and provide support as to why someone may not have a strong performance (Pelponska et al., 2017).

**State of Training**

Athlete's purposefully train to improve the level at which they can perform. Training consistently at specific intensities, durations, and load of training has the ability to adapt the physiological capabilities of an athlete beyond their baseline fitness level due to improvement and efficiency of the cardiovascular, musculoskeletal, respiratory, endocrine and immune systems (Centers for Disease Control and Prevention, 1999). The idea of adaptive homeostasis, where your body finds a modified homeostatic state at the cellular level from stress resilience brought on by exercise training, allows the body to become more efficiently trained physiologically and ultimately has a positive impact on athletic performance (Centers for Disease Control and Prevention, 1999; Davies, 2016). Training such as endurance training can lead to mitochondrial adaptations to improve performance (Bartlett, Hawley & Morton, 2015). Increase in mitochondrial mass, or mitochondrial biogenesis can increase the ability of an athlete to sustain themselves for a longer period of time. The exercise capacity within the skeletal muscle improves due to an increase in mitochondria number and size, resulting in greater production of adenosine triphosphate (ATP) for energy and more efficient fuel utilization at the cellular level (Bartlett et al., 2015).

**Sports Psychology**

Sports psychologist recognizes the psychological components of stress, anxiety, tension and aggression affect sports performance in athletes (Bali, 2015). These four factors, at certain levels, are essential in the success of competition by placing the appropriate amount of stress to perform at an athlete's relative performance (Bali, 2015, Gee, 2010). However, if levels of stress, anxiety, tension and aggression are too low or too high, performance efficiency will decrease. These psychological components follow an inverted U model that illustrate a specific point at which the athlete reaches an optimal amount of stress or pressure, anxiety, tension and aggression (Bali, 2015). Too little amount of pressure is associated with boredom and an athlete can feel unchallenged or unmotivated in their performance, where as too much pressure pushes to levels of high anxiety and an unmanageable amount of stress that is too overwhelming to perform at their best (Bali, 2015). Sports psychologists are trained professionals that can utilize techniques to manage intensified instances of; stress, anxiety, tension and aggression, helping decrease the negative effects elevated levels of these can play in athletic performance (Bali, 2015; Gee, 2010).

## Role of Nutrition in Sports Performance

Goals of training in nutrition are meant to keep an athlete well-fueled and hydrated to support training without compromising the athlete's body composition (Manore et al., 2009; Thomas et al., 2016). More specifically, nutrition is meant to meet the energy requirements to support an athlete's training program and training adaptations, which means they can be ever changing to meet the specific training periodization and an individual's goals (Thomas et al., 2016; Burke, 2007). Energy needs are going to differ by not only the athlete's body size, age and weight, but also the type of training including the frequency, intensity and duration of exercise. When all of these things are taken into consideration the proper energy requirements can help achieve an athletic specific physique, can play a role in hormonal and immune system function, and overall macronutrient and micronutrient needs (Burke, 2007). Positive body energy from both adequate protein and energy intake can supply the body's ability to perform and manufacture new muscle tissue to work towards an ideal physique (Dunford & Doyle, 2015; Burke, 2007). Aside from enhancing training adaptations, energy and key nutrients are important for the refueling and recovery during and between training sessions to delay the onset of overall fatigue and injuries during performance (Manore et al., 2009; Thomas et al., 2016; Dunford & Doyle, 2015; Burke, 2007). Increase in fatigue can increase the risk of injury, which can cause major setback in an athlete's training and competition season (Manore et al., 2009). Competing in the next bout of physical activity without adverse effects is possible through nutrition because of the bodies capabilities to use food to restore muscle and liver glycogen stores, replace fluid and electrolyte losses, and build new proteins for a variety of functions following physiological stresses of exercise (Burke, 2007).

**Energy Systems**

The body has three main energy systems that it utilizes to do physical work; creatine phosphate energy system, anaerobic glycolysis and oxidative phosphorylation. Specific movements, intensities and duration of exercises will affect which system is predominately being utilized, which in turn determines its favorable substrate fuel source (Dunford & Doyle, 2015).

**Creatine Phosphate Energy System.** The creatine phosphate energy system utilizes the nitrogen containing compound, creatine, and the breaking of a higher energy phosphate bond to create energy to support high-intensity, short duration exercises such as power events, heavy lifting, sprinting and jumping with a duration of lasting from five to ten seconds (Dunford & Doyle, 2015). The concept of creatine phosphate is related to the body's rapid contraction of skeletal muscle (Caine & Davies, 1962; Dunford & Doyle, 2015). During the process of contracting skeletal muscle, the compound creatine phosphate is hydrolyzed, splitting the phosphate from the creatine using creatine kinase (Dunford & Doyle, 2015). The free phosphate then combines with adenosine diphosphate (ADP) to form adenosine triphosphate (ATP) using ATPase (Dunford & Doyle, 2015). The ATP within the skeletal muscle will hydrolyze, breaking the high-energy phosphate bond resulting in muscle contraction (Caine & Davies, 1962). As creatine phosphate depletes, fatigue is the protective mechanism in the body to prevent complete depletion of ATP (Dunford & Doyle, 2015). The creatine phosphate system works in an anaerobic setting, or without oxygen, however, when the compound creatine phosphate needs to be replenished, it relies on an aerobic environment in the mitochondria of the muscle to form ATP, where it hydrolyzes the ATP to ADP to attach a phosphate to a creatine molecule to restore creatine phosphate (Bessman & Carpenter, 1985).

**Anaerobic Glycolysis.** Anaerobic glycolysis, or the lactic acid system is an energy system that the body utilizes carbohydrates to produce energy in the form of ATP and byproduct of lactic acid (Dunford & Doyle, 2015). This energy system is used specifically during sprint exercises that last up to two minutes in duration such as medium distance races like 200 and 400 meters or other high-intensity exercises. The key concept about this energy system is that it occurs in a non-oxygenated state and utilizes carbohydrates in the form of glucose as its main substrate. Carbohydrates are broken down through 18 chemical reactions to produce ATP and lactate (Dunford & Doyle, 2015). Lactate can be further metabolized and utilized as pyruvate and go through oxidative phosphorylation in an aerobic state (Gladden, 2004). Since the direct byproduct of anerobic glycolysis is lactate, there can be a sudden increase of lactate when exercise intensity becomes too high, pushing pass the lactate threshold and lactate is unable to be removed fast enough, accumulates and decreases the overall pH in the muscle. This is known as metabolic acidosis and results in muscle fatigue, hence why this energy system is specific to short, high intensity exercise. (Gladden, 2004; Dunford & Doyle, 2015)

**Oxidative Phosphorylation.** Oxidative phosphorylation, or aerobic energy system, continually works to supply ATP to the body within the inner mitochondrial membrane. Oxidative phosphorylation relies on mainly carbohydrates and fat that have been metabolized to go through 124 chemical reactions to produce a large quantity of ATP through two major phases. The first of the two phases in the oxidative phosphorylation energy system consists of the krebs cycle. This cycle takes the end product of pyruvate from aerobic glycolysis in the mitochondrial membrane, transports into the inner mitochondrial membrane to perform the various metabolic reactions producing both ATP and compounds known as flavin adenosine dinucleotide (FAD) and nicotinamide adenosine dinucleotide (NAD) (Dunford & Doyle, 2015). These electron-accepting compounds are critical for the second phase within this energy system known as the electron transport chain. Each FAD molecule equates to 2.5 ATP and each NAD molecule equates to 1.5 ATP (Hinkle, 2005). Carbohydrates in the form of glucose can produce up to 32 ATP (Bender & Mayes[c], 2012). Fat has the ability to be utilized as a substrate in oxidative phosphorylation in the process of beta-oxidation to produce up to 129 ATP, a significant increase compared to carbohydrates, which is why many elite runners feel they can perform more efficiently by consuming higher amounts of fat compared to carbohydrates because of the ATP production and decrease onset of fatigue that is associated with muscle glycogen depletion (Volek et al., 2015; Thomas et al., 2016). This energy system thrives in slow to moderate intensity exercise of longer duration, endurance exercises (Dunford & Doyle, 2015).

**Fuel Utilization**

In order for the body to perform physical activities, it needs to utilize food as fuel. The body is able to do this by metabolizing and storing carbohydrates, protein and fat for use later on during exercise to support the various energy systems. Depending on the main energy system being used during training and competition, will affect which nutritional component that is being utilized. Carbohydrates and fats, or lipids, are going to be your two most desired sources of fuel for the bodies energy systems. Carbohydrates is a highly dependent source of energy for athletes due to the body's efficient way of metabolizing, storing and utilizing it as energy when needed. Carbohydrates can be simple; monosaccharide and disaccharides, or complex; oligosaccharides and polysaccharides (Bender & Mayes[a], 2012). Ultimately the goal when consuming carbohydrates is to break them down into their simplest form, primarily glucose, to be taken up by cells to go through a multiple step process known as glycolysis, which can produce substrates in an aerobic or anaerobic environment (Dunford & Doyle, 2015). When glucose is taken up into liver or muscle cells, the process of glycolysis in the cytosol of the cell, takes glucose and forms lactate in a process known as anaerobic glycolysis. Within the muscle cell, lactate can actually be transferred into the blood to form pyruvate in the liver. The significance of this is pyruvate is the end product of aerobic glycolysis, and the necessary substrate the citric acid cycle to occur in the inner mitochondrial membrane of the cell to perform oxidative phosphorylation for the production of large quantities of adenosine triphosphate or ATP, the energy created from carbohydrate consumption (Bender & Mayes[b,c], 2012; Dunford & Doyle, 2015).

During times of recovery where carbohydrates are needed to replenish and restore the energy that was just utilized, the body takes carbohydrates and stores them within the liver and muscle tissue as glycogen. Glycogen is branched molecules of glucose that are waiting to be utilized for fuel. The process of storing glucose as glycogen is known as glycogenesis, which occurs in a fed state when insulin is present (Bender & Mayes[d], 2012). As glucose is consumed, it is converted to a form of glucose known as glucose 1-phosphate, the necessary form of glucose to be stored as glycogen, and becomes glycogen using a glycogen primer and enzyme glycogen synthase. Glycogen synthase allows for individual glucose molecules to connect to one another in 1→4 glycosyl units. Branching enzyme allows for glucose molecules to branch off using 1→6 glycosyl bonds and continues building 1→4 glycosyl bonds to form the branched molecule known as glycogen. This glycogen remains stored in the liver and muscle until the body recognizes the need to break it down into its glucose molecules for the production of energy in the form of ATP (Bender & Mayes[d], 2012. By consuming carbohydrate-rich foods, athletes restore the muscle glycogen they depleted and can support consistent and frequent training (Burke, Halwey, Wong & Jeukendrup, 2011).

Exercise intensity will affect what substrate is going to be utilized during exercise. In a lower intensity exercise, fat is going to be utilized due to the stimulation of lipolysis, mobilizing free fatty acids, increasing fat oxidation in an aerobic environment within the muscle (Dunford & Doyle, 2015). As exercise intensity increases, different muscle fibers are going to be used. These specific fast-twitch muscle fibers are more dependent on an anaerobic environment, an environment that carbohydrates can still produce ATP in through anaerobic glycolysis (Dunford & Doyle, 2015; Jeppesen & Kiens, 2012). For this reason, carbohydrates will the favored substrate to produce energy as exercise intensity increases (Jeppesen & Kiens, 2012). On the contrary, Brooks and Mercier, (1994), studied the balance of carbohydrates and lipids as fuel sources during exercise and ultimately connected this information to become the ‘crossover’ concept. The ‘crossover’ concept indicates that dependent on the exercise duration and intensity of said exercise, the body can utilize lipid as approximately 60% of its fuel source (Brooks, 1997; Brooks & Mercier, 1994). Intensity of exercise is determined by %$VO_2$ max, and an intensity of 45-50% $VO_2$ max, relatively, is considered a mild to moderate exercise intensity (Brooks, 1997). In this period of intensity, plasma free fatty acid rises rapidly, indicating the primary substrate being utilized for fuel during prolonged exercise (Brooks, 1997; Dunford & Doyle, 2015). A transition to above 55% $VO_2$ max is considered a mild to hard intensity, resulting in a decrease in free fatty acid substrate utilization, switching back to carbohydrate as the main contributing fuel source, concluding the 'crossover' concept (Brooks, 1997).

## Dietary Guidelines for Americans

Dietary Guidelines for Americans are general guidelines that have been placed by the U.S. Department of Health and Human Services are recommendations based on evidenced-based research of what the average adult American should follow to maintain a healthy diet and lifestyle to help decrease their risk for chronic diseases (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015). The key points of these guidelines focus on five principles: (1) follow a healthy eating pattern across the lifespan, (2) focus on variety, nutrient density and amount, (3) limit calories from added sugars and saturated fats and reduce sodium intake, (4) shift to healthier food and beverage choices, and (5) support healthy eating patterns for all (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015). Guidelines are suggested based off of a 2,000-calorie intake and look to include a variety of colorful fruits, vegetables, low-fat or free fat dairy, lean proteins and limited saturated fat, trans fats, added sugar and sodium (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015). Each of these dietary components have specific recommendations in how much should be consumed per day for the average adult following a 2,000-calorie diet. Additionally, other diets such as the Mediterranean Diet and a Vegetarian Diet are represented in the Dietary Guidelines for Americans with the food groups, subgroups and components that comprise these specific diets (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015).

Dietary Guidelines for Americans do not consider the strenuous training and increased energy and nutrient needs that come with being a competitive athlete. Training load, frequency, and recovery require more personalized and specific nutrition recommendations that do not fit the general public (Thomas et al., 2016; Dunford & Doyle, 2015; Burke, 2007). Total energy requirements, carbohydrate, protein and fat consumption is recommended to specific to each individual to mirror their nutrition and training goals and demands (Thomas et al., 2016; Dunford & Doyle, 2015; Burke 2007). Sports related recommendations for energy and macronutrient requirements for athletes and individuals who exercise has been created through years of research to create the general most guidelines for this population. Debate in the sports nutrition world over carbohydrate, protein and fat recommendations continue as more research on substrate utilization in different sports provides new insight on the body's ability to use fuel differently.

## Sports Nutrition Dietary Recommendations for Performance

Growing research in nutrition for sports performance has provided evidenced guidelines to dietetic professionals to base individualized recommendations to athletes.

This pool of research has been condensed and synthesized into a Position Paper for the use of sports specific dietitians to help athletes optimize performance in their training and competition. Positions regarding importance of individualized nutrition for each individual athlete specific to demands of training, fuel requirements, training adaptations, fuel timing, injury prevention and healing, and supplementation to benefit performance are discussed (Thomas et al., 2016).

**Total Energy Requirements**

Energy requirements or total energy requirements are going to differ by individuals, and differ even more within an individual dependent on their training periodization of intensity and duration of training, exposure to heat or cold temperatures, injuries, the athlete's fat free mass, and menstruation in female athletes (Thomas et al., 2016; Manore & Thompson, 2015). The Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine position paper on nutrition and athletic performance calculate total energy requirements by looking at an athlete's basal metabolic rate (BMR), thermic effect of food (TEF) and thermic effect of activity (TEA) to provide energy recommendations that will not only support their normal body functions, but also an athlete's performance (Thomas et al., 2016). An additional way of calculating energy needs for athletes is by using a factor of kilocalories per kilogram of body weight. Adapted from Macedonio and Dunford, (2009), energy expenditure for female athletes ranges from 30 to 50 (or more) kilocalories per kilogram of body weight per day. Ranges for energy expenditure allows for athletes to eat the appropriate number of calories depending on their training that day. Energy intake needs to be consistent with training and overall goals of an athlete. The nutrition and athletic performance position paper emphasizes the importance of overall nutritional requirements are not static (Thomas et al., 2016), meaning they can be adjusted to meet that days training and competition, as well as your overall goals which could include modifying your body composition to better aid in athletic performance. However, the importance of nutrition be personalized to the individual athlete is key. The concept of energy balance, where calories consumed equals calories expended would equate to maintenance of body weight does not always add up. The idea of energy balance needs to be thought of in a dynamic sense that there are confounding factors that will influence the equation of energy balance (Manore, 2015). Numerous factors working together to influence each sides of energy balance which ultimately influences your weight and body composition such as; total daily energy intake, composition & variety of diet, amount and type of fiber, energy density of food eaten, timing related to exercise, current eight and body comp, hormonal control of appetite, energy expenditure**,** resting metabolic rate (RMR), activities of daily living (ADL), exercise and intensity, body composition, genetics, futile energy cycles, environment and lifestyle**,** mindset playing an effect on energy intake and energy expenditure and overall nutrient sensing from the muscle, liver, fat and gut (Manore, 2015).

**Carbohydrates**

The main source of energy that the body relies on is carbohydrates. Carbohydrates fuel muscular work within the body by providing the brain and central nervous system with energy so it can continue through with movement in higher intensity exercise (Thomas et al., 2016). Depletion of muscle glycogen stores can onset fatigue and can result in worsened athletic performance (Thomas et al., 2016; Dunford & Doyle, 2015). Athletes have become more intelligent in adapting their bodies to hold more muscle glycogen to delay fatigue during competition by incorporating high carbohydrate consumption techniques with endurance exercise training (Thomas et al., 2016). Combining these two techniques helps mitochondrial biogenesis adaptations, increasing the mitochondrial size, number and oxidative enzyme capacity within the skeletal muscle improving aerobic exercise capacity (Bartlett et al., 2015; Dunford & Doyle, 2015). What this means is the body can utilize and store carbohydrates more efficiently, begin to oxidize lactate back to a product that the body can use to create more energy, and train the body to adapt to utilizing fat as a substrate for energy to spare muscle glycogen, especially in endurance athletes (Dunford & Doyle, 2015; Volek et al., 2015; Bender & Mayes[d], 2012).

Recommendations for carbohydrate needs are dependent on the athlete's sport and utilization of carbohydrates. Intensity and duration, along with total energy needs and body weight, are going to be factors in selecting the best ranges per kilogram of body weight to support an athlete's performance (Burke et al., 2011; Dunford & Doyle. 2015). Five grams per kilogram of bodyweight to 12 grams of carbohydrate per kilogram of body weight per day is the range sports dietetic professionals have deemed appropriate to help with maintenance of muscle glycogen stores (Burke et al., 2011). Recommendations will differ per individual and will often be indicated as a range of carbohydrates per day that are dependent on an athlete's performance and body composition goals, and can change depending on the period of training in an athlete's season (Thomas et al., 2016; Burke et al., 2011). Light to moderate activities with a duration of an hour or less recommend 5-7 grams per kilogram of body weight of carbohydrates per day where as moderate to high intensity exercises that can last up to three hours are going to utilize more muscle glycogen for fuel and require increased needs up to 6-10 g/kg of body weight (Burke et al., 2011, Dunford & Doyle, 2015). Ultra-endurance athletes competing for extended periods of time greater than four or five hours will require even higher amounts of carbohydrates, up to 8-12 g/kg of body weight, to help decrease the onset of fatigue associated with muscle glycogen depletion (Thomas et al., 2016; Dunford & Doyle, 2015).

**Carbohydrate Loading.** In the attempts to delay fatigue in endurance and ultra-endurance athletes, a technique known as "carbohydrate loading', was first studied in 1967 looking at glycogen supercompensation (Bergström, Hermansen, Hultman & Saltin, 1967). The technique or protocol was split into two separate phases; depletion and loading. The depletion phase focused on depleting carbohydrate stores by continuing to train with a low carbohydrate intake followed by a 3-day loading phase that decreased training, but increase carbohydrate consumption to approximately 8 grams per kilogram of body weight of carbohydrates (Bergström et al., 1967). Modifications since then have found that depletion of carbohydrate stores may not be necessary to achieve increased muscle glycogen concentrations (Sherman, Costill, Fink & Miller, 1981). Some researchers have found no significant evidence in performance improvement cycling from a low carbohydrate to a high carbohydrate consumption in elite trained athletes.

Michalczyk et al., (2019), investigated in the effects of carbohydrate loading in male division 1 basketball players after following a four-week low-carbohydrate diet contributing only 10% of total calories and then implementing one week of high carbohydrate consumption contributing 75% of total calories. Prior to either intervention, the 15 participants followed a conventional diet with the break down of macronutrients as 55% carbohydrates, 16% protein and 9% fat from their total calories that was calculated from their resting metabolic rate and total daily energy expenditure (Michalczyk et al., 2019). Findings indicated that total work capacity of these athletes decreased following the four weeks of low carbohydrate consumption, and even with consumption of a high carbohydrate diet for one week post low carbohydrate consumption, total work capacity only returned to baseline and had no overall significant improvement in peak power or time to peak power, all of which were assessed using a Wingate test (Michalczyk et al., 2019).

McInerney et al., (2005) attempted repeated super compensation spanning over five days to attempt to see if muscle glycogen stores can benefit from high carbohydrate (12 g/kilogram of body weight) intake after three exhaustive bouts of exercise (on day 1, day 3 and day 5) after a 10-12 hour overnight fast. Six subjects consumed a mixed diet prior to the start of the experiment and consumed 6 grams per kilogram of body weight of carbohydrates, a non-depletion method of carbohydrate loading more in-tune with the modified carbohydrate loading technique (Sherman et al., 1981). The five-day intervention had 48 hours in between each of the exhaustive trials and had participants consume four grams per kilogram of bodyweight of carbohydrates within 30 minutes of the exhaustive trial, and consume eight grams per kilogram of body weight for the remainder of the day (McInerney et al., 2005). Muscle glycogen context, which was determined by a muscle biopsy, pre-exhaustive trial glycogen concentration on day three were the significantly higher than day one pre-exhaustive trial muscle glycogen context and higher than day five pre-exhaustive trial muscle glycogen context (McInerney et al., 2005). Glycogen resynthesis was shown to be greater between trials on day one and day three than between day three and day five. Interestingly, initiation of high carbohydrate consumption followed day one exhaustive trials and showed a significantly higher glycogen context on day three, where as day five did not have in increase of glycogen synthesis compared to day three, questioning whether supercompensation can be repeated in such short periods of time during exhaustive training (McIerney et al., 2005). Overall exercise enhancement improved from day one to day three and even from day three to day five along with time to exhaustion increasing from day three to day five (163.5 +/- 10.3 min vs 174.7 +/-16.8 min), but even efficiently trained athletes were unable to repeatedly supercompensate their muscle glycogen stores (McInerney et al., 2005). However, this information can show supportive context that when used appropriately during an athletes training periodization, muscle glycogen synthesis has the potential to be increased and support exercise enhancement, but likely following a more modified technique of carbohydrate loading versus the classical carbohydrate loading technique.

**Protein**

Protein's focus in training is to support the constant catabolic reactions that are caused from training and enhance adaptations from training load (Thomas et al., 2016).

Requirements for protein are going to differ based on energy intake, type of sport and training, level of intensity or volume, and duration of activity due to the severity of muscle and protein breakdown in the body (Thomas et al., 2016; Dunford & Doyle, 2015). Overall protein ingestion goals are to achieve a positive nitrogen balance to repair and build skeletal muscle tissue, known as hypertrophy, when paired with adequate energy intake and resistance training (Thomas et al., 2016; Dunford & Doyle, 2015). However, the role of proteins are not only specific for muscle protein synthesis. Proteins are critical for enzyme production, production of hormones, connective tissue repair, transporting of nutrients such as oxygen, carbon dioxide, iron and fats, immune health and antibody production, acid-base pH balance, fluid balance and regulation immune system and antibody production, and fluid balance (Dunford & Doyle, 2015). When protein consumption is insufficient, these other functions of protein will play a role in negatively affecting an athlete's performance.

Protein recommendations range from 1.2 g/kg of body weight to 2.0 g/kg of body weight per day. Specific athletes such as power athletes, sprinters and bodybuilders are going to require higher protein needs due breakdown of skeletal muscle that occurs during these activities. Endurance and ultra-endurance runners are also going have increased protein needs but mainly related to the potential use of protein and amino acids as substrate during prolonged activity once muscle glycogen stores are depleted, along with sparing of fat stores. Amino acid pools will need to be replenished to help with the build-up of muscle tissue that was broken down to be used for energy production (Thomas et al., 2016; Dunford & Doyle, 2015). In athletes, the body is going to constantly synthesis and breakdown protein. This constant change is known as protein turnover (Dunford & Doyle, 2015). Balancing muscle protein synthesis (MPS) and muscle protein breakdown (MPB) is one part in determining the gain, loss or maintenance of muscle in an athlete (Phillips, 2013). Muscle protein can be broken down for various reasons such as from resistance training due to breakdown of skeletal muscle and inadequate protein-energy intake resulting in amino acids being utilized for energy (Dunford & Doyle, 2015). Without replenishment of the body's amino acid pool, these catabolic states will not allow for muscle protein synthesis due to a negative nitrogen balance from lack of protein to support an athlete's training (Tang & Phillips, 2009).

**Anabolic Window.** Timing of protein consumption is often purported to be consumed within one hour following a bout of exercise to help take advantage of muscle protein synthesis and muscle hypertrophy. This timing is known as the anabolic window, or the anabolic window of opportunity (Schoenfeld & Aragon, 2018; Dunford & Doyle, 2015). Debate as to whether this anabolic window exists continues as research further negates previous claims to whether the specific timing of protein consumption matters, or if overall protein consumption within a day is ultimately critical (Schoenfeld & Aragon, 2018; Fujita et al., 2009; Tipton et al., 2007). Further, there is additional debate as to whether ingestion of protein with carbohydrates will improve muscle growth. Some research findings suggesting there is no difference in muscle size or strength when participants consumed protein alone or with a carbohydrate source (Hulmi et al., 2015), despite the previous evidence supporting carbohydrate and protein consumption to enhancing anabolism, expediting glycogen resynthesis due to increased plasma insulin response, inhibiting of protein breakdown and in-part benefiting muscle hypertrophy (Schoenfeld & Aragon, 2018; Dunford & Doyle, 2015; Phillips & Van Loon, 2001; Stark, Lukaszuck, Prawitz, & Salacinski, 2012; Zawadzki, Yaspelkis, & Ivy, 1992).

**Fats**

Dietary recommendations for fat intake for athletes is typically the last thing that is calculated behind carbohydrates and protein (Dunford & Doyle, 2015). Most fat recommendations are represented by a percentage of total calories which is the remainder that is left following the calculation of total carbohydrates and protein (Dunford & Doyle, 2015). If looking for a baseline, general recommendations for fat intake based on grams per kilogram of body weight is 1.0 gram per kilogram of body weight, but can be higher depending on the demands of the athlete (Dunford & Doyle, 2015). Specifically, endurance athletes have the potential for increased fat intake due to their bodies trained ability to prioritize lipids and oxidize fat more efficiently to be utilized as a fuel source to spare muscle glycogen in order to delay fatigue (Dunford & Doyle, 2015). This phenomenon known as the crossover effect, switches the utilization of carbohydrates to lipids in highly trained individuals (Brooks, 1997).

**Low Carbohydrate, High Fat Diet Technique.** Debate regarding efficacy of low carbohydrate, high fat diets are often discussed between sports nutrition professionals and researchers in endurance athletes. The FASTER study or Fat Adapted Substrate use in Trained Elite Runners, is a famous study that looked at elite ultra-endurance runners and ironman triathletes and the efficiency of fat oxidation (Volek et al., 2015). These 20-elite athletes are highly trained and consumed a habitual diet for greater than six months of either low-carbohydrate diet (<20% of energy from carbohydrates and >60% of energy from fat) or a high-carbohydrate diet (>55% of energy from carbohydrates) and completed two separate exercise protocols. The first protocol was a maximal oxygen consumption test to determine their peak fat oxidation, and the second protocol was looking at metabolic responses through muscle biopsies and blood samples from before during and after a 180 minute treadmill run (Volek et al., 2015). All subjects consumed an appropriate carbohydrate concentrated beverage dependent on their experimental group (i.e. high carbohydrate versus low-carbohydrate) 90 minutes before and approximately 15 minutes after their three-hour run (Volek et al., 2015). Results indicated that average peak fat oxidation in the low-carbohydrate group was 2.3 fold higher than the high carbohydrate group, as well as overall carbohydrate oxidation was much lower in the low carbohydrate group (Volek et al., 2015). However, energy expenditure, maximum oxygen consumption, perceived exertion and glycogen repletion were all relatively similar in both groups (Volek et al. 2015). Serum lactate levels were significantly higher in the low carbohydrate athletes during the last hour of exercise which has the potential be explained by the bodies adaptive process to utilize lactate as a gluconeogenic substrate for the liver to be utilized within the Krebs cycle for energy due to limited carbohydrates and has been found in various animal studies on fat-utilization (Miller et al., 2015; Hyyppä, Saastamoinen, Pösö, 1999).

Burke et al., (2017) argues that high fat diets with low carbohydrate consumption has shown no improvement in performance, but rather a decrease in overall performance abilities related to a decrease in performance economy. Interestingly, over three weeks of intense training, world class endurance athletes showed an increase in peak aerobic capacity with increasing rates of fat oxidation during exercise (Burke et al., 2017), However, even though there was an increase in fat oxidation, there was a reduction in exercise economy, increasing the demand for oxygen at a given race speed (Burke et al., 2017). When comparing the endurance performance in endurance athletes that consumed a high-carbohydrates, either habitually or even in a periodized setting, to athletes having consumed a low carbohydrate diet, high fat diet, their ability to perform was impaired regardless of any improvement in their peak aerobic capacity (Burke et al., 2017). In a competitive setting, overall performance in the most important factor in athletic success.

**Hydration**

Hydration, similar to macronutrient recommendations, are to be individualized to the athlete and optimal to aid in overall health and performance success (Thomas et al., 2016). Fluid needs can be dependent on a variety of factors such as environment, especially warm environments, intensity and duration of exercise, and even the type of clothing an athlete is wearing (Sawka, Burke, Eichner, Maughan, Montain, & Stachenfeld, 2007). All of these factors contribute to insensible fluid losses from sweating and breathing where fluid and electrolytes need to be replenished to prevent hypohydration (Sawka et al., 2007). Poor hydration can result in decreased performance from physiological strain from lack of fluids and depleted electrolytes (Sawka & Coyle, 1999). Degradation in cognition and aerobic performance increase as the level of dehydration increases and can cause an increase in body core temperature, increased cardiovascular strain, increased glycogen utilization and altered metabolic function

(Panel of Dietary Reference Intakes for Electrolytes, Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, & Food and Nutrition Board, 2005; Sawka & Coyle, 1999).

Average fluid consumption per Dietary Reference Intakes is 2.7 liters per day for women and 3.7 liters per day for men (Panel on Dietary Reference Intakes for Electrolytes and Water, Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, & Food and Nutrition Board 2005). Additional recommendations for fluid replacement before, during and after exercise have been noted in the exercise and fluid replacement position stand to help athletes maintain euhydration, the optimal water body content per an individual (Sawka et al., 2007). The goal of hydration prior to the start of exercise is to ensure there is not a deficit of electrolytes or fluid from previous losses from exercise and to start your exercise in a euhydrated state (Sawka et al., 2007). Hydrating up to four hours before an athletic event allows the body to have urine output to be managed and return to a normal output right before the start of the event. The exercise and fluid replacement position stand recognize 5-7 mililiters per kilogram of bodyweight of fluids four hours before exercise, and another 3-5 mililiters per kilogram of bodyweight up to two hours before an event (Sawka et al., 2007). Pairing this was a sodium-containing snack can help retain fluids in athletes as well (Maughan, Leiper, Shirreffs, 1996; Ray et al., 1998; Shirreffs & Maughan, 1998).

The goal during exercise is to prevent the body from becoming dehydrated and losing more than 2% of an athlete's body weight (Sawka et al., 2007). A way to keep hydrated the best during exercise is to assess sweat losses during training to determine the fluid needs to replace losses and prevent dehydration by drinking fluids that are concentrated with carbohydrates (6-8% of calories from carbohydrates) and electrolytes (Sawka et al., 2007; Institute of Medicine, 1994). Specific electrolytes of interest include sodium, potassium, calcium, magnesium and chloride (Brouns, 1991). Following exercise, replenishing losses of fluid and electrolytes is the goal. This can be accomplished from consuming 1.5 L of fluid per kilogram of body weight with water or even sports drinks that contain carbohydrate and electrolyte concentrations in which athletes would want to replenish (Sawka et al., 2007; Shirreffs & Maughan, 1998).

**Supplementation**

Supplementation in relationship to micronutrients may or may not be necessary in the athletic population. The need for micronutrient supplementation relies mainly on the clinical need to supplement if dietary intake alone is not providing adequacy (Thomas et al., 2016). Key micronutrients such as iron, vitamin D, calcium, and antioxidants are of most concern amongst athletes, more specifically female athletes (Thomas et al., 2016). Low status of these stores leading to nutrient deficiencies can lead to compromised training capabilities associated with decreased aerobic work capacity, repair of bone tissue from stress fracture and injuries and overall growth and maintenance (Thomas et al., 2016; Lukaski, 2004). Specific athletic populations have the potential to be at an increased risk for deficiencies including athletes that restrict energy intake, participate in extreme weight loss practices, eliminate food groups, and consume inadequate nutrient dense diets (Farajian et al., 2004).

## Adherence and Adequacy of Sports Nutrition Principles and Diet

Sports nutrition continues to have supported research to provide evidenced-based recommendations for athletes to consume adequate calories, macronutrients, micronutrients and hydration so athletes can improve their performance success. However, researchers have found when investigating athlete's diets from a recall, many athletes are not exhibiting sports nutrition principles or consuming inadequately for their estimated energy needs.

### Adherence to Sports Nutrition Principles

Adherence to sports nutrition principles focuses mainly on the idea of consuming meals and snacks every 3-4 hours and within 1-4 hours before exercise and within 1 hour after exercise to help optimize nutrients to be utilized appropriately for training and competition (Hargreaves, Hawley & Jeukendrup, 2004; Thomas et al., 2016). As part of sports nutrition principles are presented in the position paper by the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine, fuel timing and frequency of energy and macronutrients are important in providing the proper components and total energy need to support their performance before, during and after exercise, as well as during specific times in their training and competition seasons (Thomas et al., 2016). Some researchers have looked into fuel or meal frequency in athletic populations. Ghloum and Haiji, (2011), found that the Kuwaiti fencing players preferred consumption of breakfast, lunch and dinner, with less than 4% of the participants (n=15) on average consuming snacks. Snacks can be an important way to consume foods every 3-4 hours, a noted a sports nutrition principle (Thomas et al., 2016).

Alves Coutinho et al., (2016), assessed percentage of calories during meals and snacks in penthalon athletes (n=56) and found that breakfast (20%), lunch (27%), and dinner (25%) had the highest percentage of total calories consumed during these main meals. Snacking during mid-morning, during exercise, after exercise and after dinner consisted of a lower percentage of total calories ranging from 1-7% of total calories contributing to snacks and fuel during and post exercise (Alves Coutinho et al.,2016). Both Martinez Reñin and Collado, (2015), and Clark et al., (2003), found interesting difference in meal consumption dependent on the type of training and time during season. Martinez Reñin and Collado, (2015) looked at Spanish soccer referees and the composition and intake during a normal day, training and game day and found that carbohydrate intake was greater on match days, potentially due to the demands during a match compared to a normal day. Clark et al., (2003) found significant differences in pre and post season consumption in terms of grams per kilogram of body weight for carbohydrates and protein, as well as overall protein and fat percentage from total calories being lower during post season.

**Adequacy of Diet**

Adequacy of diet is considered meeting macronutrient and total calorie needs that are determined per each individual based on their body weight, type of training and training specific goals (Thomas et al., 2016). Recommended ranges are often provided to athletes and researchers use these guidelines to assess whether current athletes are consuming their recommended calories and macronutrients specific to support their training needs. A variety of different researchers have found that the recommended intake seldom matches the actual intake of some athletes (Martinez Reñon, & Collado, 2015; Farajian et al., 2004; Fox et al., 2011; Clark et al., 2003; Valliant et al., 2012; Rossi et al., 2017). Martinez Reñon and Collado, (2015) divided recommendations into two recommendations; recommendation one for light physical activity (2700 calories, 371 grams of carbohydrates, 62.8 grams of protein, 30% of total calories from fat) and recommendation two for high physical activity (3600 calories, 540 grams of carbohydrates, 117.9 grams of protein and 30% of total calories from fat). Of the 35 participants, average intake was 11% less than the 2700 calorie recommendation and 33.1% less than 3600 calorie recommendation. Additionally, average carbohydrate intake was 279 grams, much lower than both recommendation one and two (Martinez Reñon & Collado, 2015).

Farajian et al., (2004), interviewed 58 aquatic athletes, swimmers and water polo players, to analyze a 24-hour recall and food frequency using the Mediterranean diet pyramid. Results found that 84% of all females and males consumed less than six grams per kilogram of body weight of carbohydrates, with the average carbohydrate intake for males being 4.5 g/kg (+/- 1.6) and 3.8 g/kg (+/- 1.2) for females (Farajian et al., 2004). Based on sports nutrition guidelines, those averages are well below the lower end of five grams per kilogram of body weight of carbohydrates (Thomas et al., 2016). Similarly, Fox et al., (2011) found NCAA division 1 strength and conditioning athletes to have consumed an inadequate carbohydrate intake of 46% (+/-2) of total calories from carbohydrates per recommendations within this study. However, protein intake was significantly higher (2.0 +/- 0.1 g/kg/d) for this population than what is recommended for a healthy adult (0.8 g/kg/d) (Fox et al., 2011). Conversely, average protein intake may have been on the higher end of recommendations for a strength athlete due to 76% of the participants indicating they consume a protein supplement with an average daily intake of 46 grams (+/-8 grams), affecting the average protein intake overall, rather than from a food dietary source (Fox et al., 2011).

Clark et al., (2003), found interesting differences in fuel consumption among NCAA division 1 female soccer players when comparing pre and post season dietary consumption. Comparing their intake to the most current sports nutrition and athletic performance position paper, pre-season average consumption of carbohydrates was 5.2 g/kg (+/- 1.1) of body weight, potentially inadequate when comparing carbohydrate needs for elite soccer players, and was even lower post season at 4.3 g/kg (+/- 1.2) (Thomas et al., 2016; Clark et al., 2003). Furthermore, average preseason protein intake was adequate at 1.4 g/kg (+/-0.3), but significantly decreased postseason to an average intake of 0.96 g/kg (+/-0.3), lower than the recommendation for an average American to consume (Dunford & Doyle, 2015; Clark et al., 2003). A NCAA division 1 volleyball team had similar findings of inadequate average of total calories (24.0 kcal/kg +/-8.6 vs 29.4 kca/kg +/- 7.5), carbohydrates (3.08 g/kg +/- 1.1 vs 4.15 g/kg +/- 1.3), protein (0.9 g/kg +/- 0.3 vs 1.14 g/kg +/- 0.3) and fat (67.4 g/day +/- 27.8 vs 69 g/day +/- 24.8) prior to and following the completion of a nutrition intervention by a sports dietitian (Valliant et al., 2012). Recommendations for energy intake (37-41 kcal/kg), total carbohydrates

(6-10 g/kg), total protein (1.2-1.7 g/kg) and total fat (87.7 +/-11.7 g/day) were not met in either pre or post intervention, however, post intervention averages for energy, carbohydrates, protein and fat increased (Valliant et al., 2012).

Rossi et al., (2017) found alike findings with pre and post nutrition education intervention dietary intake averages. The dietary intake of division 1 baseball players was collected over a 3-day period and averaged for both before and after a nutrition education intervention (Rossi et al., 2017). Diet Analysis Plus Version 10 was utilized to analyze the total energy, macronutrients and fluid intake of each player compare to the energy and macronutrient intake recommendations (Rossi et al., 2017). Both pre-intervention and post intervention analysis showed that overall intake for total energy and carbohydrates remained inadequate (Rossi et al, 2017). Protein and fat grams per day increased from pre-intervention to post-intervention, and met or exceeded the intake requirement (Rossi et al., 2017).

Although Ghloum and Haiji, (2011), found that the Kuwaiti fencer's diets they analyzed showed they consumed 47.8% (+/-1.7) of total calories from carbohydrates, indicating it is below the recommended range of 55-65% of calories from carbohydrates for this study. Interestingly, the average grams per day of carbohydrates, protein, fat and overall total calories exceeded the Recommended Daily Allowance (RDAs) in which their diets were being compared (Ghloum & Haiji, 2011). Farajian at el., (2004) found all females and 84% of males consumed inadequate carbohydrates (<6 g/kg/d) (Thomas et al., 2016). Participants on average consumed 1.4 g/kg/d of protein, per recommendations is adequate (Farajian et al., 2004; Thomas et al., 2016). Fat intake exceeded intake recommendations (20-25%) in all male participants and 81% of the female participants (Farajian et al., 2004).

## Nutrition Knowledge and Attitudes of Athletes

With evidence to support that some athletes have inadequacies in total energy, carbohydrate, protein and fat intake, it is assumed that this inability to consume adequate needs to meet training demands could likely be due to lack of knowledge regarding nutrition and sports performance and poor attitudes related to nutrition and performance (Weeden et al., 2014; Rossi et al., 2017; Dwyer et al., 2012; Mohd Elias et al., 2018; Stickler et al., 2018).

### Nutrition Knowledge of Athletes

Weeden et al., (2014), when assessing nutrition knowledge in collegiate athletes found that athletes were least likely to answer questions correctly related to foods that do not promote weight loss, function of carbohydrates, difference between fat-soluble and water-soluble vitamins, low fat diets being healthy and safety of dietary supplements. Male athletes had a higher mean knowledge score (57.3 +/- 13.4) when compared to their female counterparts (55.5 +/- 13.4) (Weeden et al., 2014). Additionally, collegiate athletes who had taken a previous college level nutrition course had higher mean knowledge scores (61.6 +/- 13) compared to collegiate athletes that had no previous college level nutrition course (55.4 +/- 13.2) (Weeden et al., 2014). Without previous knowledge, scores would likely be lower than the educated counterparts. Rossi et al., (2017), assessed sports nutrition knowledge, among other variables, in division 1 baseball players and found that prior to an educational intervention the average knowledge score was 56.7% (+/-11.4%). Following a 90-minute educational intervention and tri-weekly (over 12 weeks) 45-minute interventions in smaller groups (n=5), there was a significant difference in sports nutrition knowledge scores from pre (56.7% +/-11.7%) to post intervention (70% +/-9.4%) (Rossi et al., 2017).

Andrews et al., (2016), investigated sports nutrition knowledge among division 1 university student athletes and found the overall mean sports nutrition knowledge score was 56.9% (+/-14.3). Statistically, a 75% of higher was deemed an appropriate score for adequacy of knowledge (Torres-McGehee et al., 2012), meaning the average score indicated overall inadequacy in sports nutrition knowledge (Andrews et al., 2016). Of the 123 student-athletes that participated in this study, only 12 of them received a score of 75% of higher, indicating adequacy of sports nutrition knowledge (Andrews et al., 2016). Rossi et al., (2017) found statistical significance in sports nutrition knowledge following a 90-minute nutrition educational intervention. The average score improved from 56.7% (11.4) to 70% (9.4), providing support that nutrition knowledge can be increased with educational intervention programing (Rossi et al., 2017).

**Nutrition Attitudes of Athletes**

Although increasing sports nutrition knowledge is important to potentially improve adequacy of dietary intake of athletes, research is still finding that an individual can have the proper knowledge when it comes to fueling for successful performance, but still inadequately eat due to an additional barrier like attitudes. This can be reflective in the athlete’s mindset regarding eating its effect on performance. Interestingly, Stickler et al., (2018), collected qualitative information regarding six NCAA division 1 female cross-country runners and their eating behaviors and attitudes towards overall health. Three main themes of nutritional views, identity as a runner and psychological factors were subcategorized based on answers that participants explained during personal interviews. Athletes were aware of the importance of calorie consumption in providing energy for the body, protein's importance in recovery, and a correlation with eating adequately and performance efficiency. Many of the athletes expressed concern with the being unable to consume enough calories or concerned with consuming the appropriate amounts of macronutrients (Stickler et al., 2018). Additionally, all six participants identified that they have diet limitations in regards to either fat, extra calories, foods without value and sugar, indicating the reason being to maintain their weight and prevent weight gain, yet three of the runners contradicted their statements by indicating they do not want to avoid any foods (Stickler et al., 2018).

Dwyer at el., 2012, analyzed dietary recalls and an eating attitude test (EAT-40) to investigated elite adolescent female figure skaters and their eating attitudes. Of the 33 participants, 24% scored above a 30 on the EAT-40, suggesting a risk for a clinically significant eating pathology (Dwyer et al., 2012). Questions regarding restraints when eating were commonly answered similarly amongst the group. Eating restraints were reflective in their diet behavior, where intake for 44% (+/-19%) participants was lower than their estimated energy requirements (Dwyer et al., 2012). Participants were even as low as 566 kcal per day as reported from their three-day food records that were recorded during a two-month training period (Dwyer et al., 2012).

Mohd Elias et al., (2018) assessed sports nutrition attitude in 105 Malaysian male athletes in four different sports (cricket, football, hockey and rugby) using a 20-question assessment scoring from 1 (strongly agree) to 4 (strongly disagree) that focused on attitudes towards nutrition and sports-enhancing diets. This questionnaire was developed by Hornstrom et al., (2011) to assess knowledge, attitudes and practices (KAP) related to sports nutrition. The higher the score, the more positive an attitude the athlete was indicated to have towards sports-enhancing diets (Mohd Elias et al., 2018). There were increases in attitudes scores from pre to post-test in the experimental group that received the nutrition education intervention (Mohd Elias et al., 2018). Significant increases in attitudes scores suggest that the nutrition education influenced an increase in positive attitude regarding sports-related nutrition and decrease in the control groups KAP score from pretest to posttest (Mohd Elias et al., 2018).

**Nutrition Intervention Programs**

Knowledge base of nutrition can be varied amongst individuals depending on their source of nutrition information. These sources may also contain limited information that can make understanding concepts of nutrition difficult to the general population of athletes (Nazmi, Tseng, Robinson, Neill & Walker, 2019). Athletes need proper nutrition to support their training demands, but it becomes difficult if there is no basic foundation of nutrition to eat adequately. Weeden et al., (2014), assessed nutrition knowledge in collegiate athletes in 174 participants (female = 88, male =86). Of this population, 19% of the participants had taken a college level nutrition course and had better overall knowledge regarding carbohydrates, vitamins, sources of sodium, function of protein related to muscle growth and dietary supplements when compared to those who had not previously taken a collegiate nutrition course. Many researchers have recognized the need for implementation of educational intervention programs with the goal of improving the overall knowledge of an individual related to nutrition (Tam et al., 2019). Research has found that these programs have shown an increase in knowledge and attitude scores in athletes when the nutrition education is relevant to their performance (Rossi et al., 2017; Weeden et al., 2014). Studies continue to provide strong support that education of nutrition information can increase your overall knowledge and nutrition education interventions can be beneficial for athletes.

Rossi et al., (2017) provided a 90-minute sports nutrition education to division 1 baseball players, taking suggestions from Karpinski, (2012) academic sports nutrition course, and focused on food preparation and safety, role of macronutrients and micronutrients in performance, quality sources of macronutrients, portion sizes, timing of fuel, healthy body weight, supplementation and hydration. Findings showed improvement in sports nutrition knowledge, and although still some inadequacies in the baseball players intake, there was still an overall improvement of energy and macronutrient intake. Mohd Elias et al., (2018), developed an educational intervention similar to that of Rossi et al., (2017). Educational materials were developed to create a nutrition education intervention to assess Malaysian athlete's knowledge, attitudes and perception regarding sports nutrition and their dietary intake (Mohd Elias et al., 2018). Development of the educational materials were revised by expert nutrition panels in the field of sports nutrition and dietetics and were comprised of seven topics related to sports nutrition; food and healthy nutrition, macronutrients, micronutrients, fluid and hydration, nutritional intake before, during and after training or competition, energy balance and body weight management and dietary supplements (Mohd Elias et al., 2018). The educational intervention was split up between 7 weeks and comprised of lectures and group discussions. Between the experimental and control group, the experimental group that received the nutrition education intervention had overall more improvements in dietary intake of total calories, grams of carbohydrates, protein and fat (Mohd Elias, et al., 2018).

Valliant et al., (2012) took a different approach in nutrition intervention of NCAA division 1 volleyball players. Researchers met individually with the participants (n=11) to assess their sports nutrition knowledge. Participants nutrition knowledge was assessed out of 55 points utilizing the Reilly and Maughan sports nutrition questionnaire (Reilly & Maughan, 2007). From an individualized standpoint rather than a group setting, scores improved from the pretest (24.7 +/-5.9) to the posttest (31.5 +/-6.1) significantly (p=0.001). These findings help add support to the importance of educational interventions on the improvement of nutrition knowledge (Valliant et al., 2012).

**Change in Nutrition Behaviors and Attitudes**

The current pool of research supports the improvement of nutrition knowledge following the completion of a nutrition education intervention. However, increase in knowledge does not always correlate with improved behavior or attitudes regarding nutrition. Although Rossi et al., (2017) saw there was improvement in sports nutrition knowledge between division 1 baseball players, post intervention, their dietary intake still remained inadequate in total calories and overall macronutrients. Valliant et al., (2012) found something similarly in female division 1 volleyball players after the completion of individualized meetings with a Registered Dietitian. There were improvements in energy intake, calorie intake, protein intake and fat intake, however they were just improvements rather than meeting adequacy based on recommendations (Valliant et al. 2012; Thomas et al., 2016). Overall recommendations for energy were 37 to 41 kcals/kilogram of body weight with post intervention caloric intakes only meeting 70% (+/- 17.7%) of this recommendation for female athletes (29.4 +/- 7.5 kcal/kg) (Valliant et al., 2012). Carbohydrate intake for athletes is seldom recommended below five grams per kilogram of body weight, and Valliant et al., (2012), found that even post intervention, carbohydrate intake (4.15 +/-1.3 g/kg) did not even meet the minimum requirement of six g/kg of body weight (Valliant et al., 2012; Thomas et al., 2016).

Tam et al., (2019) completed a systematic review of effectiveness of nutrition education programs amongst 1529 athletes across various research studies to see not only if nutrition educational programs work, but what educational interventions are the most effective in improving knowledge. Of the randomized control trials, nine studies consisted of college, college division 1 or elite, Paralympic athletes that participated in an educational curriculum (Tam et al., 2019). Themes of the educational curriculums included; total energy and energy balance, macronutrient distributions, micronutrients, supplementation and ergogenic aids, myths and beliefs related to nutrition, weight management and body composition, body image, meal planning, strength training, overall healthy choices and general nutrition, pre and post nutrition, injury prevention, eating disorders and female athlete triad (Tam et al., 2019). Of these nine studies, Abood, Black and Birnbaum, (2004), collected nutrition knowledge, self-efficacy questionnaires and a 3-day recall from thirty female soccer players, (division 1 soccer team, n=15; women's swim team, n=15), to create eight sessions of nutrition education interventions around the baseline data collected. Interestingly, the sessions all included a section of self-efficacy to help the athlete feel a sense of control and capability of performing dietary behaviors and practices (Bandura, 1977). The randomly selected experimental group consisted of the division 1 female soccer team that underwent eight, one hour educational sessions over the course of eight weeks specific on topics related to; caloric intake and expenditure, macronutrients, fluids, micronutrients, diet record analysis, application of nutrition principles, eating on the road and putting all of the concepts together (Abood et al., 2004). Between the pre-test and post-test scores in the experimental group there was an increase in nutrition knowledge and self-efficacy scores, and overall more positive dietary changes following the intervention, (Abood et al., 2004).

# Chapter III

# METHODOLOGY

## Overview

The purpose of this study was to assess sports nutrition attitudes, adequacy of diet and adherence to sports nutrition principles among NCAA Division 1 female soccer players immediately before and one week after a sports nutrition education intervention. Dependent variables are defined as sports nutrition attitudes, adequacy of diet and adherence to sports nutrition principles. The Independent variable were defined as the sports nutrition education intervention. Following university Institutional Review Board (IRB) approval, this one group pretest-posttest design examined if there is a difference between sports nutrition attitudes and adherence to sports nutrition principles immediately before and one week after a sports nutrition education intervention, and the relationship between sports nutrition attitudes and adequacy of diet one week after a sports nutrition education intervention.

## Participants

The participants in this study were 22 female collegiate soccer student-athletes during their preseason training, who had previously completed a pretest-posttest nutrition education intervention conducted by the athletic department's sports dietitian and dietetic intern. Exclusion criteria included student-athletes under the age of 18, students that identify being nutrition majors, and student-athletes that did not complete both pre and post testing.

## Instrumentation

Data used for this study was obtained from a demographic questionnaire (Appendix A), Sports Nutrition Attitudes Assessment (SNAA) (Appendix B), adapted from Eating Behavior Patterns Questionnaire, (Schlundt, Hargreaves, & Buchowski, 2003), and 24-food recall questionnaire (Appendix C) utilizing the USDA's Multiple-Pass Method (USDA, 2019).

### Demographic Questionnaire

The demographic questionnaire was developed by the sports dietitian and dietetic intern and gathered information on the following: birthday, age, height, weight, ethnicity, year in school, academic major, years in soccer, field position, any previous and current college nutrition courses completed for at least 1 credit.

### Sports Nutrition Attitudes Assessment (SNAA)

The Sports Nutrition Attitudes Assessment (SNAA) was a survey asking 17 questions regarding the participant's attitude about a nutrition related to their athletic performance. This SNAA has been adapted from the Eating Behavior Patterns Questionnaire used by Utah State University, which was adapted to match this study's population from the original questionnaire by Vanderbilt University School of Medicine SODA Questionnaire (Schlundt et al., 2003). The questions were answered using a 5 scale Likert-type scale, 1 indicating strongly disagree to 5 indicating strongly agree. Only 15 of the questions were added together to compute a score, with the lowest possible SNAA score of 15 and with the highest SNAA score of 75. A higher an individual's score on the SNAA, the more positive their eating attitude was about nutrition related to their athletic performance. Two questions: (1) When I lose weight, my game day performance declines, (2) When I gain weight, my game day performance declines, were omitted from scoring. An open-ended question was asked on the bottom of the one-page questionnaire; "In a few words, describe how you believe diet impacts your performance?". For the purpose of this study, this qualitative information was not analyzed.

**24-hour Food Recall Questionnaire**

The 24-hour food recall questionnaire was conducted as a group 24-hour recall using the USDA's Multiple Pass Method (USDA, 2019). Participants completed the 24-hour recall all together as a group, allowing for all participants to recall their meals within a 24-hour time frame starting from the previous day. The food recall questionnaire consisted of time of meal and description of food and drink with quantity and preparation of that food or drink item. Participant's 24-hour food recall questionnaires were used to assess the adequacy of their diet and adherence to sports nutrition principles.

## Intervention

A 30-minute sports nutrition educational intervention (Appendix D) was provided, focusing on sports-specific training goals of the athletes, sports nutrition fueling of macronutrient components, their utilization of fuel within their soccer training and competition, timing of consuming fuel, and the negative effects inadequate nutrient intake can have on performance success.

## Procedures

After approval from the Kent State University Institutional Review Board, access was granted to analyze demographic, SNAA, and 24-hour food recall questionnaire. The data was pre-existing and was collected for the purpose of determining eating attitudes and dietary intake for future nutrition education programming specific for this group of female collegiate student-athletes.

A paper version of the questionnaires were administered to the female collegiate student-athletes during two separate meetings, once immediately before a 30-minute educational intervention and again one week succeeding the 30-minute educational intervention. Participants created their own 4-digit identification code that was documented on all of their questionnaires to help maintain anonymity.

### Data Preparation

The data collected was transcribed into an excel document created by the dietetic intern. The SNAA questionnaire for both pre and post nutrition education intervention was transcribed into the excel sheet. The 17 questions were each given a number associated with the question (the first question on the sheet being question (Q) 1, etc). The numerical values for each response from 1 to 5, 1 being strongly disagree to 5 being strongly disagree, remained the numerical code and recorded under a pre-test section and post-test section for each participant. Pre and post nutrition education intervention scores were individually added together for a minimum score of 15 and a maximum score of 75. Pre and post nutrition education intervention scores for each individual were compared and assessed for changes in attitude about nutrition related to performance.

The 24-hour food recall questionnaires were analyzed using Food Processor Nutrition and Fitness Software (Version 11.7.217) for each individual participant's 24-hour recall questionnaire from pre and post 30-minute sports nutrition education intervention to analyze the adequacy of their diet. Select foods available in the Food Processor Nutrition and Fitness Software (Version 11.7.217) were pre-determined prior to analyzing the 24-hour food recall questionnaires to ensure consistency of food items. Adequacy of their diet looked at total daily calories compared to their daily recommended requirements which were calculated for each participant. Total daily calories were based on a range of 37-40 calories per kilogram of body weight (Macedonio & Dunford, 2009). Analysis of adequacy of diet was reviewed between pre and post nutrition education intervention for changes in adequacy of diet.

The 24-hour recall questionnaires and the SNAA from both pre and post nutrition education intervention were analyzed additionally to evaluate adherence to sports nutrition principles to cumulate a score known as adherence to sports nutrition principles score. Adherence to sports nutrition principles looked at principles that correspond with questions on the SNAA such as; meal skipping (going longer than 4 hours without something to eat), eating regularly every 3-4 hours, eating meals and snack pre-training/competition, eating meals and snacks post-training/competition and hydration consumption, to the 24-hour food recall questionnaires to assess if they follow these sports nutrition principles. Each of these principles had a score associated with them that will be added together (Table 1) and compared from pre to post nutrition education intervention. The highest score of these principles is +5, indicating strong adherence to sports nutrition principles and the lowest score of these principles is 0, indicating weak adherence to sports nutrition principles.

Table 1
Adherence to Sports Nutrition Principles, Criteria and Scores[1,2]

| Sports Nutrition Principle | Sports Nutrition Principle Criteria | Criteria Met | Criteria Not Met |
|---|---|---|---|
| No Meal Skipping | No less than 5 meals/snacks consumed | +1 | 0 |
| Eat Regularly | Eating every 3-4 hours | +1 | 0 |
| Eating meals/snacks pre-training/competition | Consuming meal/snack 2 hours or less before training/competition | +1 | 0 |
| Eating meals/snack post-training/competition | Consuming meal/snack 2 hours or less after training/competition | +1 | 0 |
| Hydration consumption | Drank at least 2.7 liters of fluid | +1 | 0 |

[1]Total scores are added together for a minimum score of 0 and maximum score of 5, the higher the score indicates a stronger adherence to sports nutrition principles.
[2]Sports nutrition principles and principle criteria supported by Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance (Thomas et al., 2016); Hargreaves et al., (2004); Panel on Dietary Reference Intakes for Electrolytes and Water, Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, & Food and Nutrition Board (2009).

## Data Analysis

Data was analyzed using social sciences (SPSS) software version 25. Central tendency calculations analyzed the demographic data. Mean (*M*) and standard deviation (*SD*) was used to determine average age, height, weight, body mass index (BMI) calculated from reported height and weight, years playing soccer, and total calories. Frequencies were determined for ethnicity and current year in school.  A paired t-test was used to assess; ($H_1$) mean differences between pre and post nutrition education intervention SNAA scores, and ($H_2$) mean differences in adherence to sports nutrition principles scores between pre and post nutrition education intervention. A Pearson *r* correlation; ($H_3$) analyzed the relationship between SNAA scores and adequacy of diet. Statistical significance was set at $p \leq 0.05$.

## Chapter IV

## JOURNAL ARTICLE

### Introduction

Growth of collegiate athletics within the National Collegiate Athletic Association (NCAA) to over 19,000 intercollegiate teams (Schwarb, 2019) expanded research and recognition of genetic predisposition, state of training, sports psychology and nutrition as factors that can have influence over athletic performance success (De Moor et al., 2007; Wang et al.., 2013; Loos et al., 2015; Peplonski et al., 2017; Bartlett et al., 2015; Bali, 2015; Thomas et al., 2016). Nutrition fuels the body to support metabolic needs, training intensity, duration and recovery to replenish following the physiological demands of exercise. The utilization of carbohydrates, protein and fat have their own individual and collaborative roles in the body's energy systems to produce ATP so short duration, high intensity and endurance exercises can be performed efficiently. Athletes have increased energy needs when compared to the general population that must mirror their demands within their sport (Thomas et al., 2016; Dunford & Doyle, 2015; Burke, 2007). The Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine position paper on nutrition and athletic performance categorizes sport-specific recommendations for energy, carbohydrates, protein, fat, hydration and micronutrients of concern (Thomas et al., 2016).

The evidence supports these recommendations for athletes and their performance success, however athletes are considerably consuming inadequately compared to their calculated needs. Farajian et al., (2004), Fox et al., (2011) and Martinez Reñon and Collado, (2015) found their athletic participants consumed considerably below guideline recommendations for carbohydrates. Researchers alike found similar inadequacies of dietary intake among NCAA athletes (Clark et al., 2003; Valliant et al., 2012; Rossi et al., 2017). Nutrition education interventions and increasing the overall knowledge of nutrition to athletes was the initial thought in potentially improving their overall diet intakes. Various nutrition education interventions either in group or individual settings have been shown to improve nutrition knowledge scores significantly (Rossi et al., 2017) and overall improved adequacy of their nutrition knowledge (Andrews et al., 2016). Stickler et al., (2018) found an interesting niche of information regarding how NCAA division 1 female cross-country runners viewed the knowledge of nutrition and their actual dietary behaviors. Although participants were aware of the importance of adequate energy intake and macronutrients for fuel and recovery, participants still had diet limitations and were conscious to avoid foods that had the potential to increase their weight (Stickler et al., 2018). Similar attitudes were seen in female adolescent figure skaters where 44% (+/-19%) of the participants consumed lower than their energy requirements, even as low as 566 kcal per day (Dwyer et al., 2012). Mohd Elias et al., (2018), added to the current research that sports nutrition attitude scores can be increased from a nutrition education intervention regarding nutrition for sports, and that overall improvement of knowledge can lead to improved energy and macronutrient intake (Rossi et al., 2017; Valliant et al., 2012; Abood et al., 2004).

Thus, the aim of this present study was to assess sports nutrition attitudes, adequacy of diet and adherence to sports nutrition principles immediately before and one week after a sports nutrition education intervention. It was hypothesized that (1) there will be a improved sports nutrition attitude scores one week after a sports nutrition education intervention compared to immediately before, (2) there will be improved adherence to sports nutrition principle scores one week after a sports nutrition education intervention compared to immediately before, and (3) there will be a significant relationship between sports nutrition attitude scores and adequacy of diet one week after a sports nutrition education intervention.

## Methodology

### Participants

Participants of this study included twenty-two female collegiate soccer student-athletes that had previously completed a pretest-posttest nutrition education intervention conducted by the athletic department's sports dietitian and dietetic intern. Exclusion criteria included student-athletes under the age of 18, students indicating they are a nutrition major, and student-athletes that did not complete both pre and post testing. Of the 22 participants, one was excluded from statistical analysis for not completing both pre and post testing.

### Materials

Three paper questionnaires and a pen were provided to each participant. The questionnaires included: (1) a demographic questionnaire, (2) Sports Nutrition Attitudes Assessment (SNAA), and (3) a 24-hour food recall questionnaire.

**Demographic Questionnaire.** The first questionnaire was a demographic questionnaire. On the one-page questionnaire, participants were asked to report the following: birthday, age, height, weight, ethnicity, year in school, academic major, years in soccer, field position, any previous and current college nutrition courses completed for at least 1 credit.

**Sports Nutrition Attitude Assessment (SNAA).** The SNAA adapted from the Eating Behavior Patterns Questionnaire used by Utah State University, further adapted from the original questionnaire by Vanderbilt University School of Medicine SODA Questionnaire (Schlundt et al., 2003). The questionnaire had 17 questions that were answered using a 5 scale Likert-type scale, 1 indicating strongly disagree to 5 indicating strongly agree. Two questions were omitted from scoring: (1) When I lose weight, my game day performance declines, (2) When I gain weight, my game day performance declines, due to their subjectivity of the answer. A total of 15 questions were added together to compute a total score with the minimum SNAA score of 15 and the maximum SNAA score of 75. The higher an individual's SNAA score, the more positive their eating attitude was about nutrition related to their athletic performance.

**24-Hour Food Recall Questionnaire.** A 24-hour food recall was collected from each participant utilizing the USDA's Multiple Pass Method (USDA, 2019). Participants recalled their food and drink intake from the previous day, and completed the questionnaire by filling out sections regarding time of meal/drink, description of food/drink, quantity and preparation of that item. The 24-hour food recall questionnaire was analyzed and used to assess adequacy of the participants diet and adherence to sports nutrition principles.

**Procedures**

Following approval from Kent State University IRB, access was granted to analyze this pre-existing data. The data was originally collected for future nutrition education programming by Kent State's sports dietitian and dietetic intern. When participants completed both pre and post nutrition education questionnaires, they assigned themselves a 4-digit ID to be addressed on every questionnaire they completed to help in keeping their information confidential, but had the ability to be analyzed if needed from pre to post test. Data was used to see if there was a difference in SNAA scores and adherence to sports nutrition principles following the nutrition education. The data was also used to see if post nutrition education, there was a relationship between SNAA score and total calories consumed.

To begin analysis of the data, a master excel sheet was created. Each participants' responses were recorded for both pre and post nutrition education for their SNAA. These scores were added together for both pre and post nutrition education to determine the score from 15- 75. To determine adherence to sports nutrition principles, the 24-hour food recall questionnaires were reviewed for frequency they consumed meals/snacks, at what time they consumed a meal/snack compared to their practice times (provided by their coach), and their hydration consumption. Reviewing their 24-hour recall questionnaires against the adherence principle criteria computed a score from 1- 5 (Table 1), which was completed for both questionnaires pre and post nutrition education intervention. Total calories were calculated for both pre and post-test utilizing the Food Processor Nutrition and Fitness Software (Version 11.7.217) and were compared to each participants' recommended caloric intake of 37-40 kcals/kg of body weight (Macedonio & Dunford, 2009) for adequacy of diet.

**Data Analysis**

Data was organized and analyzed using social sciences (SPSS) software version 25. Statistical results were obtained using paired t-tests comparing: (1) differences in SNAA scores from pre to post intervention, (2) comparing differences in adherence to sports nutrition principles scores pre and post intervention. A Pearson r correlation test was used to identify the strength of the relationship between post intervention SNAA scores and adequacy of diet. Statistical significance was set at $p \leq 0.05$

## Results

*Table 2*
*SNAA Score, Adherence to Sports Nutrition Principles Scores and Adequacy of Diet*

| | *(M±SD)* | Minimum | Maximum |
|---|---|---|---|
| Pre | | | |
| SNAA Score[1] | 59.90±8.14 | 45 | 75 |
| Adherence to Sports Nutrition Principles Score[2] | 2.52±1.03 | 0 | 4 |
| Adequacy of Diet[3] | 2420.16±707.32 | 1260 | 3429 |
| Post | | | |
| SNAA Score[1] | 58.33±7.84 | 46 | 75 |
| Adherence to Sports Nutrition Principle Score[2] | 2.57±1.25 | 1 | 5 |
| Adequacy of Diet[3] | 2137.8±646.81 | 1235 | 3930 |

[1]SNAA Scores based on a Likert-type scale from 1 to 5, 1 indicating strongly disagree to 5 indicating strongly agree.
[2]Scoring criteria based on Table 1, computing a score from 0-5.
[3]Total of calories calculated from 24-hour food recall questionnaire using Food Processor Nutrition and Fitness Software (Version 11.7.217).

**Participant Demographics**

The average participants age was 19.43 years old (*M*=19.43, *SD*=1.17). The average participant body mass index (BMI) was 23.04 (*M*=23.04, *SD*=1.95). With a BMI range of 21.09 to 24.99, all participants fell within the BMI range considered healthy/normal (Table 3).

**Differences in SNAA Scores**

Overall, there were no significant differences found between SNAA scores pre nutrition education compared to SNAA score post nutrition education ($p$=0.158) (Table 4). The mean average of SNAA scores post nutrition education (58.33±7.84) were slightly lower than mean average SNAA scores pre nutrition education (59.90±8.14). It is noteworthy that both pre and post nutrition education scores were still relatively higher scores when compared to the maximum score of 75.

**Differences in Adherence to Sports Nutrition Principles Scores**

Comparing differences in sport principle adherence scores, there was no significant difference from pre and post nutrition education intervention (p=0.867) (Table 5). The mean average score for sports principle adherence scores post nutrition education (2.57±1.25) were slightly higher than sports principle adherence score pre nutrition education (2.52±1.03). The maximum score the participants could receive for sports principle adherence was a 5. Both pre and post nutrition education sports principle adherence scores were more than half of that score, indicating of the five principle on average, participants were able to meet two of the five criteria.

Table 3

*NCAA Division 1 Female Soccer Players Demographics*

| | ***M±SD*** | **Minimum** | **Maximum** | ***f*** |
|---|---|---|---|---|
| Overall (N=21) | | | | |
| Age (yrs) | 19.43±1.17 | 18 | 21 | |
| Weight (lbs) | 142.76±15.29 | 114 | 180 | |
| Height (in) | 65.95±1.99 | 61 | 69 | |
| BMI (k/m$^2$) | 23.04±1.95 | 20 | 27 | |
| Years in Soccer | 15.24±2.23 | 10 | 18 | |
| Ethnicity | | | | |
| Caucasian/White | | | | 16 |
| Black or African American | | | | 1 |
| American Indian/Alaskan Native | | | | 0 |
| Asian | | | | 1 |
| Native Hawaiian/Pacific Islander | | | | 1 |
| Bi-Racial | | | | 2 |
| Multi-Racial | | | | 0 |
| Year in School | | | | |
| Freshman | | | | 6 |
| Sophomore | | | | 4 |
| Junior | | | | 5 |
| Senior | | | | 6 |

Table 4

*Differences in SNAA Scores*[1] *from Pre to Post Nutrition Education*

| | ***N*** | ***M*±SD** | ***t*** | ***df*** | ***p*** |
|---|---|---|---|---|---|
| Attitude_pre | 21 | 59.90±8.14 | 1.47 | 20 | 0.158 |
| Attitude_post | 21 | 58.33±7.84 | 1.47 | 20 | 0.158 |

*Note:* SNAA: Sports Nutrition Attitudes Assessment

*=significant difference found at $p \leq 0.05$

[1]SNAA Scores based on a Likert-type scale from 1 to 5, 1 indicating strongly disagree to 5 indicating strongly agree.

Table 5
*Differences in Adherence to Sports Nutrition Principles Scores*

| | ***N*** | ***M±D*** | ***t*** | ***df*** | ***p*** |
|---|---|---|---|---|---|
| Adherence_pre | 21 | 2.52±1.03 | -0.17 | 20 | 0.867 |
| Adherence_Post | 21 | 2.57±1.25 | -0.17 | 20 | 0.867 |

*Note:* *= significant difference found at $p \leq 0.05$
[1]Scoring criteria based on Table 1, computing a score from 0-5.

**Relationship between Post-Education SNAA Scores and Adequacy of Diet**

A Pearson *r* correlation was conducted to examine the relationship between post-education SNAA scores and adequacy of diet. A moderate negative relationship was found between SNAA scores and adequacy of diet ($r$=-.442, $p$ = 0.045) indicating there is some relation between sports nutrition attitudes and adequacy of diet (Figure 1). With a more positive attitude about nutrition related to athletic performance, there was a decrease in total calories consumed one-week post-education.

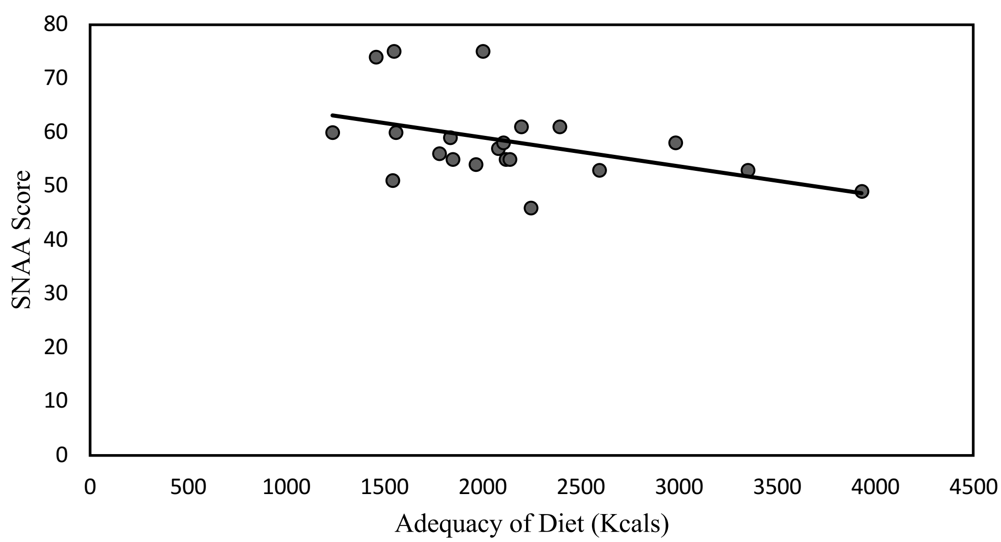


*Figure 1.* Relationship Between Post and SNAA Scores & Adequacy of Diet

**Discussion**

The relationship between sports nutrition attitude scores and adequacy of diet one week after a sports nutrition education intervention hypothesis was the only hypothesis accepted within this study. The two other hypothesis regarding improved SNAA scores one week after a sports nutrition education intervention and improved adherence to sports nutrition principles one week after a sports nutrition education intervention were rejected. Following the educational intervention, the post SNAA scores were not significantly different than the pre SNAA scores, however pre and post intervention averages were still relatively high compared to the maximum score of 75. Looking at the score based on percentage out of 100 percent, pre intervention average scores were approximately 77.8% and post intervention average scores were approximately 79.8%, showing a small increase in score averages. Although this current study was unable to find significant differences in attitudes scores related to sports nutrition for performance, Mohd Elias et al., (2018), were able to find significant increases in attitude scores following nutrition education lectures and discussion groups over the course of seven weeks. Within this current study we were unable to provide sustained educational sessions over the course of many weeks, but this could have potentially led to a significant increase in SNAA scores indicating a significance in a more positive attitude related to nutrition for sports performance.

An important thing to note is Mohd Elias et al., (2018), used only male participants within their study, whereas this current study used only female participants. When looking at studies that used predominately female participants, we can see different themes have the potential to influence dietary behaviors, even though the athlete may have knowledge of nutrition. Stickler et al., (2018), found athletes had diet limitations to help in the maintenance of weight even though they understood the importance of calories in performance efficiency. Dwyer et al., (2012), similarly found female participants concerned with diet limitations and eating restraints. Something this current study did not investigate was restrictive eating patterns, disordered eating and body image. Based on findings from Stickler et al., (2018) and Dwyer et al., (2012), there is potential the participants in this current study experienced similar thoughts to the participants in those studies. Maybe the additional factors of body image, weight and body composition play another role in their attitude about nutrition in their sports performance, and is reflective in their overall behaviors of adherence to sports nutrition principles and adequacy of their diets.

There was no significant difference found from pre to post nutrition education intervention adherence to sports nutrition principle scores. Adherence to sports nutrition principles scores were taken during the preseason training of the participants, which is a regimented schedule of practices. This may have been difficult for participants eat no less than 5 meals per day and to eat meals every 3-4 hours if the timing fell during practice times. Following the intervention only 47.61% of the participants consumed 5 or more meals. Some participants recorded consuming carbohydrate containing beverages such as chocolate milk, Gatorade or Body Armour during a separate meal time. For the purpose of this study, chocolate milk was included as a meal/snack but the other beverages were not considered a meal or a snack and just counted towards total fluid intake. Some participants did consume meals every so many hours such as four and a half to five hours, but it was not in the set criteria range of 3-4 hours for this current study so they were unable to be scored in that criteria. When looking at percentage of participants from pre compared to post nutrition education intervention adherence to sports nutrition principles score for individual criteria, after the intervention, each criteria percentage was improved, however there was not a significant improvement from pre to post. Interestingly, pre intervention (28.57%) compared to post intervention (33.33%) of participants consumed a meal or snack 2 hrs or less prior to training, which was much lower than the percentage of participants consuming a meal or snack 2 hrs or less after exercise. One hundred percent of the participants consumed a meal or snack 2 hours or less after training post nutrition education intervention, an increase from 95.23% pre nutrition education intervention. This looks similar to Alves Coutinho et al., (2016) and their assessment of calories at each meal, finding that lunch and dinner contained the higher percentage of calories for a meal or snack, similar to the participants in this current study. Many of the participants in this current study consumed lunch and dinner due to it following their practice resulting in higher consumption of calories compared to their breakfast before training.

Consumption of carbohydrates and protein following training and competition provide muscle glycogen restoration and maintenance of positive protein nitrogen balance for skeletal muscle tissue in the anabolic window following exercise, although this is a debated topic, is still a technique that should be encouraged to make sure athletes are receiving adequate nutrients (Thomas et al., 2016; Schoenfeld & Aragon, 2018; Fujita et al., 2009; Tipton et al., 2007). If there were to be a reassessment of these same participants during their regular season rather than preseason, there may have been findings to suggest variations of intake depending on the difficulty of their practice, a travel day or game day, which is what Martinez Reñin and Collado, (2015) found in the Spanish soccer referees they studied. Preseason trainings are regimented and exhausting, and created specific times for when the athletes were to be eating in between practices. Within a college semester, an athlete must create their own schedule when it comes to fueling with food. Had we done this research during their season between practices and games, I have a strong anchoring our results would have been much different. However, even with how regimented the female athlete's schedules were, participants still only averaged around meeting 2.5 out of 5 of the criteria. That could be seen as a concern if participants, with a prepared schedule, are not eating frequently or at the appropriate times during the day. This leads into the question of the adequacy of the diet within these athletes.

Overall, when total calorie recommendations were assessed for each individual athlete and compared against the average consumption based on 37-40 kcal/kg of body weight (2401-2596 kcal/day) (Thomas et al., 2016), the average intake before the nutrition education intervention was within the lower range of recommendations (2420.16±707.32). Post nutrition education diet adequacy was much lower than pre-intervention and guideline recommendations (2137.8±646.81) indicating there is a lack of adequacy in the diet for these student-athletes. Some athletes were consuming as low as 1200 kcals (pre: 1260 kcal; post: 1235 kcal), almost half of the average caloric recommendation. Further, adequacy of diet goes deeper than just total calories, the consideration of macronutrient breakdown of carbohydrates, protein, fat, hydration and micronutrient levels encompass all components to determine an overall adequate diet for an individual and was not analyzed within this study. As the data in this current study has shown, there was no significant difference in their sports nutrition attitudes assessment scores and they were actually lower following an educational intervention.

This study could help provide support that an educational intervention that spans over time talking about key nutrition components may be more successful in increasing the scores closer to the maximum score of 75. Similar findings were found in two other studies looking at NCAA collegiate athletes, although took different approaches as interventions. Rossi et al., (2017) found that even completing a 90-minute nutrition education intervention, and four more 45-minute educational sessions over 12 weeks improved nutrition knowledge, but the participants still remained inadequate in their caloric and macronutrient consumption. Valliant et al., (2012) had individualized educational interventions with the female participants and also found improvements in energy intake, protein and fat intake, but they were still not adequate based on recommendations (Thomas et al., 2016). Total caloric intake was only meeting 70% (+/-17.7%) of their recommendations, with the average carbohydrate intake being lower than the minimum recommendation (4.15+/-1.3g/kg/d) (Valliant et al., 2012). The current study's data has shown, within this small population, following the nutrition education, the more positive their attitude about nutrition related to sports performance, the lower total calories that were consumed. However, these participants did not consume an adequate diet based on the operational definition of an adequate diet being total calories. What this means is that based on these participants, a more positive attitude about sports nutrition related to performance, the fewer calories consumed amongst the athletes. Does this fall back on lack of what adequacy in nutrition looks like? Does nutrition knowledge need to be improved regarding adequacy within the diet? We have seen within the research the improvement of nutrition knowledge from educational sessions and some improvements in intakes of macronutrients and energy, but none of which are considered adequate based on evidence-based recommendations. It is discussed within this paper and other research that attitudes can hinder the behavior of dietary consumption, but overall with increased knowledge and a more positive attitude, behaviors are not changing significantly. In order to take athletes from simply just improving their intake to meeting their intake adequately, there is the potential need for behavior modification interlaced with nutrition education. Further research into the utilizing behavior modification methods to improve consumption and adequacy in the diet of athletes to meet their nutrition recommendations needs to be studied.

## Application

Registered Dietitian Nutritionists (RDNs) can utilize this information to help understand the attitudes athletes have towards nutrition and their athletic performance, and factors that can overall influence their behavior to consume an adequate diet. An educational intervention has the potential to be more beneficial by having consistent sessions over the course of several weeks over a variety of topics rather than all at once in a one-day short intervention. A lecture style intervention may not have been the most productive way to reach the participants in helping change their perspective of nutrition for their performance. In order to have changed behavior in adequacy of a diet, behavior modification techniques or overall behavioral therapy techniques should be implemented if RDNs want to have changed, lasting behavior. Nutrition education to improve knowledge is not the main issue. Education is important for the basis of knowledge and understanding, but knowledge and understanding may not reflect in behavior. Interventions need to be consistent, focusing on knowledge and behavior changes so that it is seen in dietary choices and consumption. A large part of what dietitians do within their scope of practice is consult and nutrition counsel, however, there is not an emphasis in current coursework focusing on behavior modification and therapy techniques unless taken within a psychology department. We need to make these courses a main part of our learning curriculum because it is seen throughout practice.

We can learn from this current study that the intervention may not have been sufficient when compared to longer duration interventions that are more involved and allow athletes hands-on experience in preparing food and fueling for their performance and recovery. RDN's can also utilize this information to support the need for implementation of fueling stations available to all athletes to promote consumption of food before and following practices and trainings. Dietitians working with the athletes can take advantage of the fueling station and provide mini nutrition educations to athletes to receive an optimal food item that would best suit their pre or post performance needs. Consistent educations and helping athletes understand why that specific food is important can bring beneficial changes to athletes in their training and performance goals.

## Limitations

Various limitations were presented from reviewing the pre-existing data for this study. Most of the limitations were related to the 24-hour food recall questionnaire and the overall accuracy of the information on the questionnaire. Having been a 24-hour recall rather than the participants documenting at the time of the meal, the participants were going off of memory which leads to the potential of misinformation or forgetting items they consumed over the 24-hour period, inaccurately representing their total calorie intake. Additionally, some of the participants failed to describe food items extensively, leading to just general food items being selected in the food processor system (i.e. salad). Some food items were also mis-quantified, such as stating "1 tsp of broccoli", the participant likely did not consume only 1 tsp of broccoli. The 24-hour food recall questionnaire also lead to some limitations related to adherence to sports nutrition principles such as a participant may have met the criteria's for no less than 5 meals/snack, eating every 3-4 hours and consuming food at least 2 hours before and 2 hours after practice. However, that is not to denote that some of these food choices may be less desirable than others such as candy or other energy dense food items compared to their nutrient dense counterparts.

## Conclusions

The findings of the current study have shown no significant difference in sports nutrition attitudes scores and adherence to sports nutrition principles between before and one week after a sports nutrition education intervention. There was a significant relationship between a more positive sports nutrition attitude and lower caloric intake.

Average caloric intake was inadequate among participants and there is potential that athletes have little understanding of dietary adequacy for their individualized needs. This information emphasizes the need for improved nutrition education interventions that pair with behavior modification and therapy techniques that can help athletes not only develop nutrition knowledge and a positive attitude about nutrition, but the skill set and behaviors to consume an adequate diet that adheres to sports nutrition principles for the benefit of their performance.

# APPENDICES

# APPENDIX A

# DEMOGRAPHIC QUESTIONNAIRE

**Appendix A**
**Demographic Questionnaire**

# Demographic Questionnaire

4-Digit ID #: ___ ___ ___ ___

Birthday: ________________

Age: _______

Height: _______

Weight: _______

Ethnicity:
- ____White
- ____Black or African American
- ____American Indian or Alaska Native
- ____Asian
- ____Native Hawaiian or Other Pacific Islander
- ____Bi-racial
- ____Multi-racial

Year in School: _______

Academic Major: ______________________________

Years in Soccer: _______

Field Position: __________________

Any Previous and/or Current College Nutrition Courses Completed For at least 1 Credit:

Circle: Yes No

If yes, please list courses below

## APPENDIX B

## SPORTS NUTRITION ATTITUDES ASSESSMENT

**Appendix B**
**Sports Nutrition Attitudes Assessment (SNAA)**

**Sports Nutrition Attitudes Assessment**

Birthdate ______________________________ 4-digit ID ____________________

***Attitudes*** – Consider how *you* feel your diet impacts your soccer and indicate your level of agreement with each statement listed below.

| | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| Eating well positively impacts my **practice** performance. | 1 | 2 | 3 | 4 | 5 |
| When I eat a meal or snack at least 1 hour before training, I feel I have a better workout. | 1 | 2 | 3 | 4 | 5 |
| When I skip meals it negatively impacts my **practice** performance. | 1 | 2 | 3 | 4 | 5 |
| When I eat regularly (every 3-4 hours) it helps me improve my **body composition**. | 1 | 2 | 3 | 4 | 5 |
| When I eat regularly (every 3-4 hours) I have better **concentration** during practices and games. | 1 | 2 | 3 | 4 | 5 |
| I feel that my diet impacts my immune system. | 1 | 2 | 3 | 4 | 5 |
| I believe my diet can reduce my risk of injury. | 1 | 2 | 3 | 4 | 5 |
| When I eat regularly (every 3-4 hours) I feel that I perform better in practice and workouts. | 1 | 2 | 3 | 4 | 5 |
| When I don't eat an adequate meal after practice and games, it negatively impacts my performance **the next day.** | 1 | 2 | 3 | 4 | 5 |
| When I **lose weight,** my game day performance declines. | 1 | 2 | 3 | 4 | 5 |
| When I am **dehydrated**, my game day performance declines. | 1 | 2 | 3 | 4 | 5 |
| When I **gain weight**, my game day performance declines. | 1 | 2 | 3 | 4 | 5 |
| When I get **6-7 hours of sleep**, my training is positively impacted. | 1 | 2 | 3 | 4 | 5 |
| I see positive changes in my training when I eat well after training. | 1 | 2 | 3 | 4 | 5 |
| My food choices on game days significantly impact my game performance. | 1 | 2 | 3 | 4 | 5 |
| I am conscious about the food choices I make before practices and games. | 1 | 2 | 3 | 4 | 5 |
| When I eat carbohydrates, I have more energy to compete . | 1 | 2 | 3 | 4 | 5 |

In a few words, describe how you believe diet impacts your sports performance?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

# APPENDIX C

# 24-HOUR FOOD RECALL QUESTIONNAIRE

## Appendix C
## 24-Hour Food Recall Questionnaire

4 Digit ID # ___ ___ ___ ___

**Food Record (24-hour Recall)**

| Time | Food/Drink | Description | Preparation | Amount |
|---|---|---|---|---|
| | | | | |
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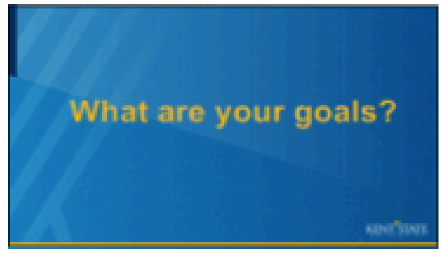
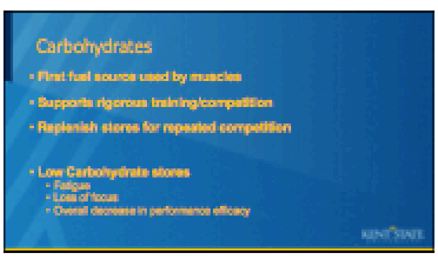
# APPENDIX D

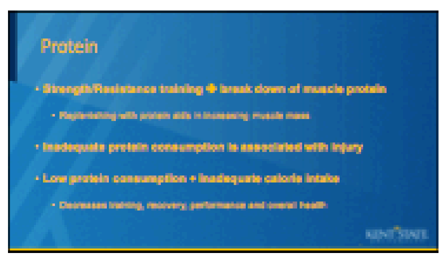
# EDUCATION INTERVENTION PRESENTATION

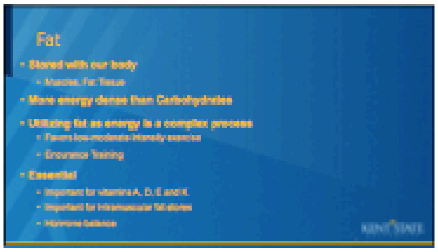
**Appendix D**
**Education Intervention Presentation**

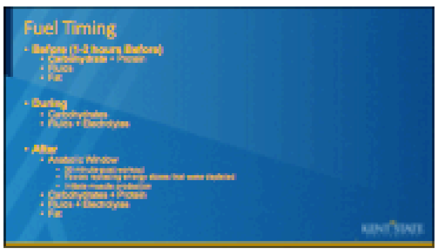


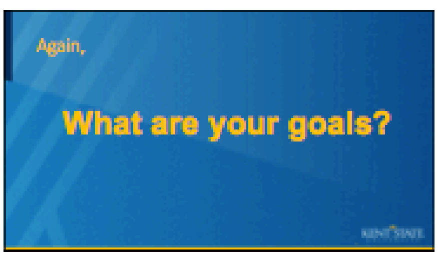



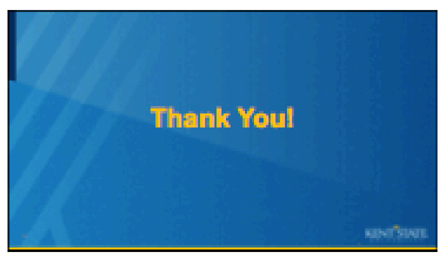

Fat
Stored with our body
Muscles, Fat Tissue
More energy dense than Carbohydrates
Utilizing fat as energy is a complex process
Favors low-moderate intensity exercise
Endurance Training
Essential
Important for vitamins A, D, E and K
Important for intramuscular fat stores
Hormone balance


Hydration
Important to replenish fluid and electrolyte losses
Poor hydration
Loss of concentration
Loss of coordination
Loss of endurance capacity
Decreased performance
Muscle cramps
Increases strain during exercise


Fuel Timing
Before (1-3 hours Before)
Carbohydrate + Protein
Fluids
Fat
During
Carbohydrates
Fluids + Electrolytes
After
Anabolic Window
Carbohydrates + Protein
Fluids + Electrolytes
Fat


USA Women's Soccer Team
High-quality lean protein
High-quality carbohydrates
Salads and greens
Fruits, vegetables
Recovery Drink
Post high-intensity on-field practice: High carbohydrate content
Post Lift: High protein content


Again,
What are your goals?


Thank You!

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