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# Effects of a sport nutrition education intervention on nutritional knowledge, dietary behaviors, and self-efficacy in NCAA Division I softball players

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# EFFECTS OF A SPORT NUTRITION EDUCATION INTERVENTION ON NUTRITIONAL KNOWLEDGE, DIETARY BEHAVIORS, AND SELF-EFFICACY IN NCAA DIVISION I SOFTBALL PLAYERS

An Abstract of a Thesis

Submitted

in Partial Fulfillment

of the Requirements for the Degree

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ABSTRACT

Optimal nutrition is vital in sport. The purpose of this study was to investigate the effects of a sport nutrition education intervention (SNEI) on nutritional knowledge, dietary behaviors, nutritional self-efficacy, body composition, and performance in National Collegiate Athletic Association Division I female softball players, and to measure retention and effects of this knowledge after the SNEI period. Seven participants were assessed using a Dietary Behaviors and Nutritional Knowledge questionnaire, Self-Efficacy questionnaire, BodPod measurement, exit velocity, and weekly intention surveys. Two-way mixed repeated ANOVAs were used to determine the impact of a five-week SNEI on an intervention group as compared to a control. One-way repeated measures ANOVAs were used to assess changes from pretest to posttest to retention. The results support existing literature that collegiate athletes score relatively low on nutritional knowledge assessments, and nutrition education can increase nutritional knowledge and self-efficacy scores. However, increases in nutritional knowledge and self-efficacy scores, in combination with high intentions to eat proper diets for sport performance, are not sufficient to see significant changes in dietary behaviors over a nine-week period. Consequently, body composition and exit velocity were also unchanged. Additionally, nutritional knowledge and self-efficacy were retained at three weeks post intervention, suggesting that a short-term SNEI may be sufficient to see prolonged improvement in these measures. Further research is needed to understand best practices in SNEI structure that will successfully improve and sustain favorable dietary behaviors in athletes, leading to improved body composition and performance in sport.

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# CHAPTER I

# INTRODUCTION

## Background

Optimal nutrition is vital in sport. Athletes need proper nutrition to fuel the daily energetic demands required of their bodies for both individual performance and team success. The athlete requires a specific modified nutrition plan than what is required of nonathletes, including increased caloric intakes through higher consumptions of macronutrients and careful attention to hydration (Thomas, Erdman, & Burke, 2016). Previous research has established that optimal nutrition is a key component for peak athletic performance (Garthe, Raastad, & Sundgot-Borgen, 2011; Hinton, Sanford, Davidson, Yakushko, & Beck, 2004; Hornstrom, Friesen, Ellery, & Pike, 2011), whereas deficiencies in nutrition may lead to decreased performance, and puts the athlete at risk for developing injuries (Rauh, Nichols, & Barrack, 2010; Zawila, Steib, & Hoogenboom, 2003). The changes in body composition that accompany modifications in diet are associated with the increased or decreased performances related to nutrition.

Theoretically, changes in dietary habits lead to changes in body composition. This is relevant in sport, wherein certain body mass proportions (e.g., reduced fat mass, high lean body mass) have been shown to increase power and performance in athletes (Garthe, Raastad, & Sundgot-Borgen, 2011; Rossi et al., 2017). Without proper nutrition, athletes risk being unable to perform at their highest levels and achieve success in their sport. However, through manipulations of dietary habits, athletes can alter body composition favorably. The latter assumes that athletes are aware of how diet influences performance, know how to properly fuel for performance, and that they successfully consume a diet that will assist them in attaining peak performance.

To attain information about sport nutrition, athletes consult a variety of sources. These sources include athletic trainers, coaches, parents, teammates, and an assortment of platforms available online (Rosenbloom, Jonnalagadda, & Skinner, 2002; Torres-McGehee et al., 2012; Zawila et al., 2003). However, despite seeking nutrition information from various sources, research has principally shown that athletes have inadequate sport nutrition knowledge, including less than optimal hydration knowledge (Dunn, Turner, & Denny, 2007; Hornstrom et al., 2011; Jonnalagadda, Rosenbloom, & Skinner, 2001; Nichols, Jonnalagadda, Rosenbloom, & Trinkaus, 2005; Rosenbloom et al., 2002; Torres-McGehee et al., 2012), and inconsistent results in supplementation knowledge (Trakman, Forsyth, Devlin, & Belski, 2016).

To address the general lack of sport nutrition knowledge among athletes, researchers have assessed the effects of sport nutrition education on dietary habits and performance by providing athletes structured sport nutrition education interventions (SNEIs). The outcomes of these investigations show that SNEIs increase nutritional knowledge (Abood, Black, & Birnbaum, 2004; Chapman, Toma, Tuveson, & Jacob, 1997; Cholewa, Landreth, Beam, Jones, & MacDonald, 2015; Collison, Kuczmarski, & Vickery, 1996; Doyle-Lucas & Davy, 2011; Martinelli, 2013; Nascimento et al., 2016; Patton-Lopez, Manore, Branscum, Meng, & Wong, 2018; Rossi et al., 2017; Siti, Saad, Taib, & Jamil, 2018; Tam et al., 2019; Valliant, Emplaincourt, Wenzel, & Garner, 2012; Yannakoulia, Sitara, & Matalas, 2002), which is as expected. However, conflicting results exist on how nutrition education influences dietary habits, body composition, and subsequently performance. For example, Garthe, Raastad, and Sundgot-Borgen (2011) concluded that favorable body composition changes occurred in athletes after eight to 10 weeks of a nutritional intervention, while the control group experienced no significant changes in body composition. Others have echoed this finding in regard to changes in dietary behaviors or body composition (Buffington, Melnyk, Morales, Lords, & Zupan, 2016; Doyle-Lucas & Davy, 2011; Nascimento et al., 2016; Patton-Lopez et al., 2018; Yannakoulia et al., 2002).

Alternatively, Collison and colleagues (1996) noted that although SNEIs increase sport nutrition knowledge in athletes, translation into improved dietary habits is not consistent, which has also been reiterated by others (Chapman et al., 1997; Martinelli, 2013). Other studies have reinforced this notion by examining the effects on performance (e.g., Folasire, Akomolafe, & Sanusi, 2015). Folasire and colleagues demonstrated that performance did not correlate positively with increased nutritional knowledge, wherein they used handgrip strength as the measure of performance. However, this measure may not be fully representative of the body composition changes that occur with diets favorable to sport performance following changes in nutritional knowledge, and represents the general lack of consistent measure usage in regard to nutrition education and its outcomes.

Additionally, few studies have assessed sport nutrition knowledge beyond the immediate posttest. Collison et al. (1996) used a three-month period after a nutrition education intervention to test retention in collegiate female athletes. In both Collison and colleagues' study and Doyle-Lucas and Davy's (2011) study, nutritional knowledge at the retention test was significantly higher than at pretest, and not significantly different than at posttest, suggesting that knowledge was retained. Yet others have noted an apparent decline in retention of nutritional knowledge after the posttest (Yannakoulia et al., 2002), suggesting a potential need to supplement knowledge over time.

Additionally, while translation into practice was not assessed in Collison and colleagues' (1996) work, it has been studied scantly with athletes in other studies with conflicting conclusions. Doyle-Lucas and Davy (2011) concluded that dietary habits in dancers declined at retention compared to posttest, but were still significantly higher than baseline, while Yannakoulia and colleagues (2002) concluded that dietary behaviors (e.g., dieting, food preoccupation) were decreased after intervention, but nutrient intakes were unchanged. Although scarce with athletes, the effects of a nutritional knowledge intervention over time have also been studied in other populations.

Matvienko, Lewis, and Schafer (2001) extended on nutritional knowledge retention by examining dietary habits after retention periods in undergraduate females who took a nutrition course one year after the posttest. Participants in the education intervention group consumed fewer calories per day compared to the control group at the end of the intervention. These differences, however, were not found to be significant at the one-year check-in, and participants in the intervention group showed a decline in retention of nutritional knowledge from posttest, similar to Yannakoulia and colleagues' (2002) study with dancers. These results suggest that ongoing nutritional education may be necessary to maintain adequate nutritional knowledge and see continued maintenance or changes in dietary habits and body composition over time. While previous research indicates that the impacts of a nutritional education intervention can result in physical and behavioral changes in the long term (Brink & Sobal, 1994; Matvienko et al., 2001), the effects are not well established among athletic populations.

Additionally, physical changes may not be the only change associated with nutritional knowledge. Athletes' nutritional choices may be related to psychological perceptions of themselves, such as perceived nutritional self-efficacy. An individual's self-efficacy is "conviction that one can successfully execute the behavior required to produce outcomes," (Bandura, 1977, p. 193). Previous literature has linked self-efficacy with nutritional tendencies, suggesting that self-efficacy is an important contributor in dietary habits (Anderson, Winett, & Wojcik, 2007; Poddar, Hosig, Anderson, Nickols-Richardson, & Duncan, 2010).

However, research is limited on nutritional self-efficacy among collegiate athletes, particularly as it relates to SNEIs (Abood et al., 2004; Bolles, 2008; Karpinski, 2011; Martinelli, 2013). Existing literature on self-efficacy among collegiate athletes shows an average score of 70% on self-efficacy measurements, suggesting a general lack of confidence in making nutritional choices (Abood et al., 2004; Bolles, 2008; Karpinski, 2011). However, research also suggests that exposure to nutrition information, regardless of delivery method, can increase self-efficacy (Karpinski, 2011). These results confirm trends seen in earlier studies wherein collegiate athletes who received an SNEI with elements of self-efficacy emphasized showed a significant increase in self-efficacy related to nutrition as compared to the control groups (Abood et al., 2004; Bolles, 2008).

The explicit influence of nutritional education on nutritional knowledge, self-efficacy, dietary habits and body composition from these studies is not clear, as the studies on these topics employ many different populations, measures, and formats of intervention. However, these factors warrant more investigation, as increases in self-efficacy are known precursors to behavioral changes, such as dietary habits (Abood et al., 2004). Understanding more details on the outcomes of SNEIs is a key component in providing athletes a comprehensive plan for improving sport performance over time.

## Statement of Problem

To consume proper nutrition for their sport, athletes need to be knowledgeable about how to fuel with food and drinks. The relationship between increased nutritional knowledge and dietary habits is heavily researched, with some concluding that higher nutritional knowledge is related to better dietary habits even if intakes are still below those required of athletes for their sport (Abood et al., 2004; Alaunyte, Perry, & Aubrey, 2015; Hinton et al., 2004; Hornstrom et al., 2011; Jonnalagadda et al., 2001; Nichols et al., 2005; Rosenbloom et al., 2002; Torres-McGehee et al., 2012), while others show that improvements in knowledge do not appear to alter dietary habits (Chapman et al., 1997; Collison et al., 1996; Martinelli, 2013). However, regardless of where they receive their information from, 91% of the student athletes in Zawila et al. (2003) reported that, ‘‘Learning facts about nutrition is the best way to achieve favorable changes in food habits,” (p. 69). Therefore, athletes need sufficient knowledge about how to fuel for sport to have the opportunity to alter their dietary habits and maximize performance potential based on changes in body composition.

SNEIs are abundant in the literature (Abood et al., 2004; Chapman et al., 1997; Cholewa et al., 2015; Collison et al., 1996; Doyle-Lucas & Davy, 2011; Martinelli, 2013; Nascimento et al., 2016; Patton-Lopez et al., 2018; Rossi et al., 2017; Siti et al., 2018; Valliant et al., 2012; Yannakoulia et al., 2002). These previous studies suggest that sport nutrition knowledge is increased in athletes at the end of the intervention period. However, it is important that the individual maintains this knowledge even after the intervention period has passed to maintain optimal nutritional habits and experience long-term changes in body composition (Matvienko et al., 2001), and possibly performance (Folasire et al., 2015). This aspect has not been well established among athletic populations, as existing studies are scant and present conflicting results (Collison et al., 1996; Doyle-Lucas & Davy, 2011; Yannakoulia et al., 2002). Furthermore, nutritional self-efficacy in relation to nutritional knowledge changes over time among athletes are scarce in the literature (Abood et al., 2004; Bolles, 2008; Karpinski, 2011), but may provide key insight on how to increase the translation of nutritional knowledge into dietary habits.

## Purpose

The purpose of this study was to investigate the effects of an SNEI on nutritional knowledge, perceived nutritional self-efficacy, dietary habits, body composition, and performance in National Collegiate Athletic Association (NCAA) Division I female softball players, and to measure retention and effects of this knowledge after the SNEI period. The results are intended to serve as a foundation for educating female collegiate athletes on how to properly fuel for sport, with focus on how to alter body composition for increased performance potential over a period of time.

## Operational Definitions

- Athlete: individual who engages in sport or physical exercise
- Body composition: an individual's proportions of adipose tissue and muscle within the body
- Dietary habits: typical daily intake of nutrients
- Endurance athlete: athletes who exert primarily submaximal efforts over longer periods of time (e.g., cross country runner)
- Exit velocity: ball velocity after contact with bat
- Healthy diet: based on topics and recommendations provided within the intervention
- Light activity: less than 3 metabolic equivalents (METs; e.g., slow walking)
- Moderate activity: 3-6 METs (e.g., brisk walking, cycling at 10-12 mph)
- Nutritional knowledge: knowledge pertaining to best practices for dietary intakes; includes major categories of macronutrients, micronutrients, hydration, supplementation, and caloric intakes
- Self-efficacy: one's perceived ability to control an outcome
- Sport nutrition: nutrition specifically formulated to support individuals who engage in sport or physical exercise

- Sport nutrition education intervention (SNEI): formal instruction on dietary requirements needed to support optimal performance in individuals who engage in sport or physical exercise
- Strength and power sport athlete: athlete involved in sports characterized by intermittent bursts of high intensity activity (e.g., weightlifter, shot put thrower)
- Team sport athlete: athlete involved in team sports, which are often characterized by repeated, intermittent bursts of high intensity activity (e.g., softball, football)

## Research Questions and Hypotheses

Based on the literature review, the following research questions and hypotheses are put forth:

1. Does an SNEI improve nutritional knowledge in female Division I softball players over time?

- Participants will score higher on the posttest than the pretest in nutritional knowledge following an SNEI.
- Participants will not score differently on the retention test than the posttest, but still higher than the pretest on nutritional knowledge.
- Participants who complete an SNEI will score higher in nutritional knowledge as compared to a control.

2. Does an SNEI improve perceived self-efficacy in female Division I softball players over time?

- Perceived self-efficacy in nutrition will be increased at posttest as compared to pretest.

- Perceived self-efficacy in nutrition will be increased at retention test as compared to pretest.
- Perceived self-efficacy in nutrition will be increased at retention test as compared to posttest.
- Participants who complete an SNEI will score higher in perceived self-efficacy as compared to a control.

3. Does an SNEI improve dietary behaviors in female Division I softball players over time?

- Dietary behaviors will be increased at posttest and retention as compared to pretest.
- Dietary behaviors will be increased at retention tests as compared to posttest.
- Participants who complete an SNEI will score higher in favorable dietary behaviors as compared to a control.

4. Does an SNEI improve body composition in female Division I softball players over time?

- Body composition will be more favorable (i.e., increased lean mass, decreased fat mass) at posttest and retention as compared to pretest.
- Body composition will be more favorable (i.e., increased lean mass, decreased fat mass) at retention test as compared to posttest.
- Participants who complete an SNEI will have more favorable body compositions (i.e., increased lean mass, decreased fat mass) as compared to a control.

5. Does an SNEI improve exit velocity in female Division I softball players over time?

- Exit velocity will be increased at posttest and retention as compared to pretest.
- Exit velocity will be increased at retention test as compared to posttest.
- Participants who complete an SNEI will have increased exit velocities as compared to a control.

## Assumptions

All participants are assumed to have given a full and honest effort in completing the pretest, posttest, and retention questionnaires. They are also assumed to have followed all instructions for body composition testing in the hours leading up to the test (i.e., fasting 2 hours prior to test, limit physical activity) for the baseline, posttest, and retention measurements. Participants are assumed to have not engaged in other sport nutrition talks or classes, or share information with participants in groups other than their own.

## Limitations

This study does not account for previous nutrition education exposure by participants. Those who are interested in sport nutrition or have taken courses related to nutrition may already practice good dietary habits, and therefore not have significant changes in body composition or self-efficacy. This may also contribute to participation bias. These individuals may also not score significantly higher on the posttest as compared to the pretest. Additionally, Division I athletes tend to exhibit body compositions close to what is considered optimal for sport. Changes in body composition resulting from better nutritional knowledge may not be significant. Lastly, the environment outside of the SNEIs is not controlled, and participants may engage in behaviors outside of the group that contribute to changes in body composition or self-efficacy.

## Delimitations

This study was conducted to determine if sport nutrition education influences nutritional knowledge, self-efficacy, dietary habits, body composition, and performance. The participants included in this investigation are NCAA Division I female softball players. The instruments used are Reilly and Maughan's (2007) *Dietary Behaviors and Nutrition Knowledge Questionnaire, Self-efficacy Questionnaire* (Abood et al., 2004), and portions of the *Collegiate Athlete Survey of Nutritional Diets* (Pawlak, Malinauskas, & Rivera, 2009).

# CHAPTER II

# REVIEW OF THE LITERATURE

## Introduction

This literature review includes several areas of discussion to outline the rationale for the proposed study on nutritional knowledge, self-efficacy, dietary habits, body composition, and performance as related to SNEIs. Body composition and its relationship to performance are discussed, followed by nutritional recommendations for athletes to achieve optimal body composition in sport. Next are the reported dietary intakes, depth of knowledge, and sources of information for collegiate athletes. This is followed by the relationship between nutritional knowledge, dietary habits, and body composition, and psychological principles influencing nutritional behavior. Lastly, principles related to learning and retention are discussed as a premise for understanding how educational interventions may best be structured.

## Body Composition

Body composition is the measured amount of different masses within the body (i.e., fat, muscle). It is a measure that is relevant for health, as certain measurements could imply poor dietary habits or insufficient dietary intakes. For example, female athletes with low percentages of body fat are at risk for developing the Female Athlete Triad, wherein their reproductive and overall health may be compromised, leading to decreases in performance (Rauh et al., 2010; Zawila et al., 2003). Alternatively, lower-fat and higher-lean muscle mass percentages are associated with power, which is beneficial in a variety of sports (Copic, Dopsaj, Ivanovic, Nešic, & Jaric, 2014; Garthe, Raastad, &

Sundgot-Borgen, 2011). Therefore, the manipulation of body composition is an important factor in achieving success in sport performance.

Body composition can be measured using various techniques. The technique used for assessment depends on the purpose of the data and technology available. Three broad categories of measurement exist: direct, indirect, and doubly indirect (Ackland et al., 2012). Direct measurements assess tissue directly, as through use of a cadaver, and are the most accurate measurement of body composition. Indirect measurements use correlated parameters to assess the amount of tissues present, while doubly indirect measurements use the relationship between two indirect measures and established mathematical equations to estimate the amount of tissues present. Within these broad categories exist specific techniques of assessing body composition. The most widely used measures in athletic populations fall within the indirect and doubly indirect measurement categories, as they are typically noninvasive and practical for common usage.

Doubly Indirect Methods

Doubly indirect methods of estimating body composition are most common due to ease of attainment and cost. Low-technology options for measurement include anthropometric measures such as skinfold measurements and body mass index (BMI). While these measures are quick and easy to obtain, their reliability should be interpreted with caution. There are numerous calculations that exist to estimate body composition from anthropometric measurements that vary based on population characteristics (e.g., race, gender; Guppy & Wallace, 2012; Heyward, 2001). Each of these equations assumes body mass distribution is the same for all individuals within the chosen population.

Anthropometric error estimations are known to be ± 3.5% in females, and ± 5% in males as compared to more accurate methods (i.e., underwater weighing; Brodie, Moscrip, & Hutcheon, 1998).

A second common instrument for estimating body composition doubly-indirectly is bioelectrical impedance analysis (BIA). BIA uses electrodes placed on the wrists and ankles to supply a small electrical current through the body, and can utilize single- or multi-frequency signals depending on the exact instrument (Brodie et al., 1998; Levenhagen et al., 1999). The signal generated in BIA is impeded by fat mass, while it encounters much less resistance as it passes through conductive lean muscle mass. The BIA instrument uses the impedance values from the current, as well as user-entered anthropometric measures, to estimate lean body mass. As with other doubly indirect measures, the calculations are based on previously researched populations that may not be accurate for any given individual. Example characteristics that influence these equations include age, activity level, and health status (Guppy & Wallace, 2012). BIA estimations are also affected by hydration status; wherein hypohydrated individuals may obtain overestimates of body fat percentage. If all controllable variables are regulated and proper equations for the population are chosen, the percent error in estimated body fat are three to five percent (Brodie et al., 1998).

Indirect Methods

Although doubly indirect methods of estimating body composition are acceptable, indirect measurements may provide more accurate estimations. There are a variety of laboratory methods that exist for measuring body composition indirectly that are commonly used for assessing athletes. Dual energy x-ray absorptiometry (DXA) uses filtered x-ray beams to detect bone, muscle, and fat mass in an individual (Ackland et al., 2012). It is an ideal measurement for body composition due to its ability to provide quick, accurate results. However, it is not ideal for all athletes. Athletes with outlier physical parameters (i.e., smaller/larger than average, excessively lean, taller than 192 centimeters, obese) may not receive accurate readings due to the standard algorithms of the machine, or they may be too large to fit on the machine appropriately. The error estimate of measuring percent body fat using DXA is considered to be 1.2% (Heyward, 2001). Although a more accurate technique than doubly indirect methods, few labs have DXA on-site. However, many labs do have access to other equipment such as those used in densitometry.

Densitometry is a well-established laboratory technique used to assess body composition. Specifically, underwater weighing (UWW) and air displacement plethysmography (ADP) can be used to estimate fat mass based on measurements of body density and a series of established calculations.

In UWW, the participant is submerged underwater and instructed to maximally exhale to residual lung volume (RV). The body density is then calculated using the body mass, body volume measured, RV, and estimated gas volume trapped in the gastrointestinal tract (Brodie et al., 1998; Heyward, 2001). UWW is considered to be the "gold standard" in estimating body composition, as the percent body fat estimate is deemed to be within 0.7% (Heyward, 2001). However, this accuracy is attained under precisely regulated variables, including measured RV opposed to predicted RV obtained from established equations. Total body mass, underwater weight, and water temperature must also be precisely measured. Any variance in these measures can result in error estimates larger than 0.7%, therefore making the experience and preciseness of the researcher(s) an influential variable. Although highly accurate, some participants may find UWW unpleasant, or may not be able to successfully exhale to RV for multiple trials and produce accurate readings. Fortunately, ADP is considered comparably accurate while being less involved and user-friendlier.

As a more participant-friendly technique, ADP is a commonly used method for assessing body composition in athletes. Participants are not required to exhale maximally or submerge themselves underwater, which may positively influence individuals' willingness to participate in research. In ADP, similar calculations are performed as UWW, but in a sealed air capsule. The current ADP instrument available for use is called the BodPod (Life Measurement Inc., Concord, CA, USA). ADP utilizes an encapsulated chamber of known air volume at room temperature (Kenney, Wilmore, & Costill, 2015). Once the participant is sealed within the chamber, the new volume of air is determined and subtracted from the total volume. The known density of the individual is then used in a series of calculations to determine fat mass and lean muscle mass. Error estimates for ADP in males is considered to be 16% less body fat percentage in males, and 7% more body fat percentage in females compared to UWW (Levenhagen et al., 1999). However, Levenhagen and colleagues suggest that there is no mean difference between body fat percentages estimated from ADP. Additionally, when compared to other methods of attaining body composition estimates, body fat estimates from ADP are highly correlated with those obtained from UWW, BIA, and DXA across a variety of body fat percentages in adults ($r > 0.90$). In light of these reasons, ADP was chosen as the method for obtaining body composition measurements for athletes in this study.

## Body Composition and Sport Performance

Body composition is a direct result of physical activity and dietary intakes. Structured training programs and in sport can be designed to alter body composition in athletes towards ratios favorable for sport performance. The improvements in performance following these types of training programs among athletes have been supported with previous research.

Garthe, Raastad, Refsnes, Koivisto, and Sundgot-Borgen, (2011) investigated weight loss and lean muscle mass increase in athletes. Athletes were divided into groups of fast-reduction (FR) and slow-reduction (SR) of weight loss per week. The athletes completed a four- to 12- week intervention wherein they restricted their energy intakes and completed strength training protocols that would help them achieve their weight loss goal as dictated by nutritionists and exercise physiologists. The SR group's diets were not as restricted as the FR group, as their weight loss goals were over a longer period of time. At the end of the study, both groups experienced reduced body weights, with the FR group losing weight more rapidly, as expected. The SR group experienced significant increases in lean body mass during the intervention period, thought to be from a less restricted diet. The SR group also experienced significantly higher increases in lean body mass as compared to the FR group. These changes in body composition then translated into increases in performance, wherein the SR group experienced larger increases in countermovement jump height, 40-m sprint time, and 1-repetition max (RM) weight lifted in bench press, bench pull, and squat.

Similar increases in performance variables following body composition changes have also been studied in female team sport athletes, perhaps most extensively in volleyball. González-Ravé, Arija, & Clemente-Suarez (2011) examined professional volleyball players over a period of 24 weeks, spanning both off-season and in-season. The off-season workouts were designed to elicit hypertrophy, whereas in-season workouts were designed to elicit explosive strength and power. The overall result of workouts from both time periods showed increases in lean body mass and decreases in fat mass. Performance measures also increased. Athletes showed overall increases in jumping performance (vertical jump, squat jump, countermovement jump, Abalakov jump) and maximal strength (2-RM back squat). However, despite these overall positive changes, there were no individual correlations between the two variables.

These performance results are similar to those found by Copic and colleagues (2014), who investigated the relationship between body composition, leg strength, and jump performance in elite volleyball players and nonathletes. However, results from this study did find strong correlations in that leg extensor strength, percent body fat, and percent lean muscle mass were predictors of jumping performance in both the elite and nonathlete group. Despite some contradictions in results, these studies demonstrate that changes in body mass composition have an effect on performance variables related to power and success in sport. While these studies are specific to volleyball athletes, it is not unreasonable to suggest that the observed positive changes in performance variables (i.e., strength, power) reflected from changes in body composition could apply to athletes in other sports involving strength and power where populations are not studied as considerably, such as softball.

Although softball specific research in regard to body composition and performance appears to be more limited than other female sports, it has not been overlooked entirely. Cahill and Jones (2010) conducted performance tests (vertical jump, hang clean, bench press, front squat, pro agility, and 300-yd shuttle run) in NCAA Division I female softball players. They also acquired body mass composition estimates from the athletes. The data from the study revealed several significant correlations. Body composition was negatively related to vertical jump, whereas body composition was positively correlated with the pro agility and 300-yard shuttle run. The results from their findings suggest that performance is influenced by body composition, and that body composition could be a determinant of what position a softball player is best suited for, as some positions require more speed and agility than others. Additionally, these correlations are relevant as the performance tests used in this study are often employed by sports programs to assess current conditioning and fitness levels of their athletes, which underlie success in various sports.

Similarly, Nimphius, McGuigan, and Newton (2012) investigated performance changes associated with 20 weeks of softball-specific training, and the correlations between percent changes in muscle architecture measurements and percent changes in strength, speed, and change of direction performance. Participants completed three-RM (loaded and unloaded) in jump squats. These values were used to predict 1-RM, peak force, peak velocity, and peak power in the participants. Additionally, values for first and second base sprinting performance, change of direction, aerobic capacity, and muscle architecture characteristics of the vastus lateralis (i.e., muscle thickness, fascicle length, pennation angle) were measured. Over the 20-week period, participants experienced significant increases in 1-RM (absolute and relative), change in direction on the non-dominant side, and second base sprinting performance. These significant increases in performance were considered to be from underlying changes in muscle architecture. Relevant to body composition, significant relationships between vastus lateralis muscle thickness and first base sprint performance, and vastus lateralis fiber length and second base sprint performance were found, suggesting improvements in certain performance variables were due to hypertrophy of the muscles.

Other studies have assessed more specific softball-related measures with regard to body composition. Lowe et al. (2010) investigated how body composition relates to bat swing velocity, which is considered to be a determining factor in successful hitting (Breen, 1967). Lowe and colleagues collected anthropometric data from participants, including height, body mass, fat mass, lean muscle mass. They also used values of handgrip strength, lower body power (from vertical jump assessments), and batted ball velocity. The results from their analyses revealed significant relationships between bat swing velocity and body mass, lean body mass, and body fat. These relationships suggest that although a direct causative effect cannot be established from the correlations, a significant relationship exists between body composition ratios and bat swing velocities in NCAA Division I female softball players. Similarly, Till et al. (2011) also found significant relationships between body composition and bat swing velocity. Results from their study with Division I female softball players showed significant correlations between bat swing velocity and peak power (from vertical jump), 1-RM hang clean, body mass, and body fat. Additionally, they found that throwing velocity of the participants correlated significantly with 1-RM dumbbell row.

The overall consensus from the surveyed literature suggests that body composition exerts a significant influence over performance variables that are instrumental for success in sport, particularly softball. The increases in swing velocities from more favorable body compositions for sport are contributing factors to increases in exit velocities (i.e., velocity of the ball after leaving the bat), which contribute to the distance a ball will travel after being hit. Due to its relative ease of collection, exit velocity data was used as the performance indicator in this study.

## Fueling for Performance

Body composition is an essential component of performance, and can be achieved through manipulation in dietary intake. The primary component of nutrition for athletes is energy intake (EI). EI refers to the caloric intake of an individual on a daily basis. The food and drink that an athlete consumes contributes to EI, and allows the body to fuel itself for necessary metabolic functions, sport performance, training adaptations, and recovery (Isretel, Davis, Case, & Hoffman, 2018). When the EI is inadequate to fuel energetic demands, the body can utilize stored energy from fat deposits, or other tissues such as protein. Chronically, poor nutritional habits, such as insufficient or excessive energy intake can compromise health and negatively alter body composition

(Jonnalagadda, Skinner, & Moore, 2004; Rossi, Shamah, Fleming, & Christiano, 2015). Optimal dietary intake for performance is dynamic, but can be achieved through manipulation of macronutrients, micronutrients, and hydration, which vary based on activity type, level, previous dieting and training history, motivation, and individual goals.

Carbohydrates

Carbohydrates are considered the main substrate for providing energy in high intensity and extended physical activity. This is due to the metabolic system's ability to rapidly convert carbohydrates into usable energy substrate to fuel activity (Bergström & Hultman, 1966; Thomas et al., 2016). Additionally, carbohydrates can support a wide range of intensities, as they can be metabolized both anaerobically and oxidatively. Upon consumption, carbohydrates can be used immediately as an energy source, or stored in the liver and muscles as glycogen for later use. Carbohydrates consumed in excess of saturating glycogen stores initiates *de novo* lipogenesis, wherein the excess carbohydrates are converted into fat and stored in the body (Acheson et al., 1988). The consumption of appropriate carbohydrate amounts therefore prevents unwanted fat gain, as well as protects other tissues from being broken down for energy, which is particularly relevant for athletes as they participate in energetically demanding activities and rely on lean muscle mass for performance. Additionally, anabolism of lean muscle mass is mediated by carbohydrates, wherein the intensity of physical activity allowed from carbohydrate consumption results in increased energy for training adaptations and recovery (Isretel et al., 2018). Similarly, prolonged and intermittent high-intensity physical activity performance can be influenced by manipulation of carbohydrate stores, wherein decreased carbohydrate availability is linked with muscular and mental fatigue, and reduced work rates in physical activity (Thomas et al., 2016).

The recommended daily intake (RDI) for carbohydrates in athletes varies based on the types and intensities of activities. For endurance and team sport athletes, the RDI is minimally 1.5 grams per pound of body weight, but can range up to 3.0 grams per pound on days where training intensity and demand is high (Isretel et al., 2018). The 1.5 to 3.0 grams per pound per day also encompasses athletes in strength and power sports, wherein the RDI is 2.5 grams per pound.

Protein

Skeletal muscle, composed of protein, is highly plastic with daily turnover rates of one to two percent (van Loon, 2013). Any physical activity increases muscle protein synthesis (MPS). However, physical activity also increases muscle protein breakdown (MPB; Phillips, Tipton, Aarsland, Wolf, & Wolfe, 1997). Therefore, protein must be consumed in the diet to fuel MPS rates superior to MPB rates, allowing for muscle maintenance or hypertrophy. This is relevant for athletes, as lean muscle mass is related to power (Copic et al., 2014; Garthe, Raastad, & Sundgot-Borgen, 2011).

The RDI for protein in athletes vary based on demands of the sport. For endurance athletes, the RDI is between 0.5 and 1.0 grams per pound, with an average 0.7 grams per pound appropriate for moderate training. Team sport athletes are recommended to consume 0.6 to 1.5 grams per pound daily. However, 1.5 grams per pound is considered the recommendation on occasions where physical activity is at a maximum, and 0.8 grams per pound is considered to be the average amount of protein required daily. Strength and power sport athletes are recommended to consume 0.7 to 2.0 grams per pound per day, with the average intake around 1.0 grams per pound. The exact amount depends on the intensities and volumes of the physical activities, as well as degree of muscle damage and individual goals of the athlete. For example, an athlete trying to gain muscle mass may fall in the higher end of the recommended range.

Additionally, the athlete may need to consider the sources of protein. Whey protein has been shown to have superior MPS rates as compared to soy and casein, thought to be due to its rapid and easy digestion (Tang, Moore, Kujbida, Tarnopolsky, & Phillips, 2009). Specifically, food sources high in leucine may be most beneficial, as leucine has been researched in rats to be a key amino acid in MPS (Anthony, Anthony, & Layman, 1999). Rapid digestion leads to more availability in the bloodstream in a shorter amount of time, which is relevant for athletes based on studies suggesting that MPS is highest in the immediate hours post-exercise (van Loon, 2013). Such foods include eggs, dairy, legumes, and meat like poultry and fish.

Fats

The consumption of fat plays an indirect role in facilitating body composition changes favorable to sport performance. Fat is essential in the body, as it acts as a signal for testosterone and estrogen production (Isretel et al., 2018). These hormones are important for achieving desired lean muscle mass, as they act as mediators in muscle synthesis, repair, retention, and attenuation (Enns & Tiidus, 2010; Griggs et al., 1989).

Upon consumption, fat may be used as energy or stored for later use as adipose tissue (Kenney et al., 2015). Two categories of fat exist in relation to storage: essential and nonessential. Essential fat is used to support normal physiological functioning, while nonessential fat can help contribute to energy production for physical activity. While fat provides more calories per gram as compared to carbohydrates (9 kcal v. 4 kcal), the metabolic conversion of fat in to usable energy for the tissues is significantly slower.

Still, adequate dietary intake of fat contributes to achieving optimal health and performance. The RDI for fat in athletes varies based on the types of activities involved in. For endurance sport athletes, team sport athletes, and athletes involved in strength and power sports, the RDI is minimally 0.3 grams per pound of body weight (Isretel et al., 2018). The maximum value for daily fat intake is as much as allowed under the caloric constraint hypothesis for that individual, which is discussed below.

Caloric Constraint Hypothesis

Establishing the total calorie intake is the driving component in developing a nutritional plan, as the energy needed to meet physical demands of athletes is most important. However, the ratio of the three macronutrients categories within total calorie intake also exerts significant influence. This balance is called the Caloric Constraint Hypothesis (CCH; Isretel et al., 2018). The CCH works on the premise that the macronutrient ratios within the total calorie count should be manipulated based on individual body composition and performance goals. Within the CCH, the athlete should be eating at least the recommended daily minimums for each macronutrient. Then, based on the types of activities involved in and performance goals, the athlete can manipulate the ratio of each macronutrient to meet their total caloric intake goal. General ratios for athletes include consuming approximately 60% of calories from carbohydrates and 20 to 35% fat, assuming that energy requirements and minimum intakes of macronutrients are met (Rodriguez, DiMarco, & Langley, 2009). Still, these percentages will vary individually.

Micronutrients

Micronutrients are essential for facilitating metabolic processes and muscle adaptations. They include the primary subclasses of vitamins and minerals. They do not contribute to daily caloric intake, but are considered necessary in daily consumption.

Vitamins are organic compounds that primarily cannot be synthesized endogenously (Kenney et al., 2015). They can be categorized as fat-soluble or water-soluble. The fat-soluble vitamins include A, D, E, and K. To be utilized by the body, these vitamins must combine with dietary fat, demonstrating the importance of adequate fat intake in athletes. The water-soluble vitamins include B-complex vitamins and vitamin C. These vitamins are absorbed into the bloodstream from the digestive tract.

Minerals are inorganic compounds that also cannot be synthesized endogenously. They can be categorized as macrominerals or microminerals. Macrominerals are minerals where more than 100-milligrams are required by the body per day, whereas microminerals are needed in amounts less than 100-milligrams daily. Although there are numerous minerals, those of interest relative to exercise include calcium, phosphorus, iron, sodium, potassium, and chloride. While each mineral serves a different purpose within the body, their overall role is to support metabolic processes such as growth, repair, and energy production.

Both vitamins and minerals provide indirect benefits to performance by protecting athletes from the harms to health caused by insufficient intake and supporting growth and repair. When athletes are consuming balanced diets that support their energy expenditures, supplementation of vitamins and minerals is not typically deemed necessary (Kenney et al., 2015; Thomas et al., 2016). However, athletes who fail to consume enough calories or make poor dietary choices may be at risk for inadequate intakes of micronutrients. Even then, athletes are encouraged to consult with medical professionals to diagnose insufficiencies and strategies for supplementation of specific vitamins and minerals.

## Supplements

In addition to supplementing with vitamins and minerals, athletes may engage in other supplement use to boost performance, maintain health, or achieve macronutrient recommendations (Maughan et al., 2018). No unanimous definition for dietary supplements exist, but the International Olympic Committee puts forward that a dietary supplement is “a food, food component, nutrient, or nonfood compound that is purposefully ingested in addition to the habitually-consumed diet with the aim of achieving a specific health and/or performance benefit,” (Maughan et al., 2018, p. 105). This definition allows room for many different types of supplements and is the likely reason why there is such high prevalence of supplement use among athletes. Examples of dietary supplements aside from vitamins and minerals include caffeine, protein, beta-alanine, and creatine among many others.

When considering knowledge of supplements, athletes do not score consistently high or low (Trakman et al., 2016). However, like many other measures related to knowledge assessment, there is an inconsistent use of measures making it difficult for comparison. Some researchers have noted that athletes who receive nutritional counseling seem to make better choices regarding supplement use (Wardenaar et al., 2017). Therefore, education on supplements should be a pertinent component of a comprehensive SNEI.

Nutrient Timing

To a lesser extent as compared to macronutrient counting, nutrient timing has a significant effect on manipulating body composition for sport by providing the energy needed to perform at high levels and facilitate adaptations to exercise (Isretel et al., 2018; Thomas et al., 2016). The exact strategies for nutrient timing vary widely based on the individual and their daily physical activities. However, the most generalized approach is to consume between 4 and 8 evenly spaced meals per day (Isretel et al., 2018). This strategy is designed to fuel the energetic demands of the body without causing breakdown of tissue from long periods of fasting, or storage of fat based on excess calorie ingestion. However, collegiate athletes have unique schedules and access to food. For example, they may be limited in times they can dedicate to food preparation and eating based on schedule conflicts, access to grocery stores, and availability of dining hall hours

(Hinton et al., 2004). Therefore, the exact meal number and timings may vary daily, making execution of meal timing difficult.

Regardless, athletes should specifically plan ahead for the meals surrounding their physical activity to receive the most benefits from their training and performance. Prior to activity, athletes need to consider how rapidly digestible their nutrients are, as well as how long before the activity they should eat. Several hours before exercise, athletes can choose foods that take longer to digest and release energy slowly (Isretel et al., 2018). Up to 30 minutes before activity, however, athletes should choose foods that are easily digestible and provide quick energy to fuel their session. During exercise, consumption of food is not recommended unless the session lasts longer than 60 minutes. In this case, rapidly digesting carbohydrates should be considered, as well small amounts of protein for some athletes. Post training, food is used to replenish lost stores and facilitate physiological adaptations from exercise. Once the athlete is able to ingest food post exercise, they should selectively choose foods with carbohydrates and protein, as the muscles are primed to use these fuels. Ideally, this window is between 30 minutes to one-hour post exercise. These are general recommendations for athletes, which can be further tailored based on individual activities and performance goals.

Hydration

Hydration is important for athletes from both a health and performance perspective. While the average daily water loss varies for different individuals, the average range for adults is between 2.5 to 4.0 liters per day in resting conditions. This is from perspiration, breathing, and losses through urination and defecation. The most variable factor of water loss is considered to be perspiration, which becomes relevant for athletes. While the most universal recommendation for hydration is to drink when you are thirsty, it may not be enough to prevent hypohydration (Popkin, D'Anci, & Rosenberg, 2010; Roy, 2013). Athletes should consider hydration strategies for before, during, and after exercise to achieve optimal performances.

Athletes are recommended to consume approximately two to four milliliters per pound of body weight in the two to four hours prior to exercise (Thomas et al., 2016). The exact amount varies based on the individual and activity, such as whether the activity will be high or low intensity. The goal is to be hydrated enough to excrete pale yellow urine, and allow enough time for any extra fluid consumed to be excreted prior to exercise.

During exercise, the need to replenish fluid is dependent on sweat losses. This varies based on a variety of factors, including environmental factors, intensity and length of activity, gender, and individual sweat rates (Thomas et al., 2016). Males typically exhibit higher sweat rates than women, and likely reach hypohydration earlier, however overall fluid intake should keep the athlete within a two percent loss of body weight from perspiration (Hazelhurst & Claassen, 2006; Thomas et al., 2016). Athletes should aim between 0.4 to 0.8 liters per hour for hydration during exercise, but this range should be customized for the individual athlete's needs and demands of the activity. Additionally, for exercise lasting longer than 90 minutes, or in situations where sweat losses are great, athletes should consider consuming liquids with carbohydrates, such as sports drinks (Kenefick, 2018).

After exercise, athletes should consume liquids that primarily contain water and sodium (Thomas et al., 2016). Although hydration is important, athletes can consume other fluids that contribute to increased plasma volume, particularly those that contain sodium. Athletes should aim for 1.25 to 1.50 liters for every one-kilogram of body weight lost during exercise. Athletes should never, however, drink so much that they gain weight. This could lead to potentially dangerous conditions, like exercise-associated hyponatremia (Kenefick, 2018).

Hypohydration has potential to decrease performance when body mass loss is within the two to four percent range (Nuccio, Barnes, Carter, & Baker, 2017). Previous research on the effects of hypohydration show conflicting results related to cognitive performance. Some cognitive functions (e.g., decision-making speed, reactive agility) are suggested to be impaired by hypohydration, whereas others (e.g., mental concentration, fine motor speed) show no decline. Additionally, hypohydration of two to four percent has been shown to decrease anaerobic power and intermittent running, but further research has been deemed necessary by experts in the field to reach more certain conclusions.

### Inadequate Intake

Optimal nutrition is vital in performance. However, it also plays a role in preventing health issues (Rauh et al., 2010; Zawila et al., 2003). Specifically, less than ideal nutrition can lead to fatigue and poor performance, and diagnosable conditions in severe cases, such as those associated with the Female Athlete Triad (i.e., low energy availability, amenorrhea, and low bone mineral density). Although optimal nutrition is vital, collegiate female athletes are reported to have significant deficiencies in energy intake as compared to caloric needs (Shriver, Betts, & Wollenberg, 2013). Reasons for failure to consume recommended nutritional amounts are complex, including social and psychological factors, and lack of sufficient nutritional knowledge.

A primary reason for inadequate intakes is to lose weight. Previous research suggests that the majority of female collegiate athletes have a desire to lose weight, despite having current weights considered to be healthy (Hinton et al., 2004; Shriver et al., 2013). Additionally, Shriver et al. reported that approximately 25% of their female participants reported avoiding weight gain by restricting their protein and carbohydrate intakes. While weight loss alone is not necessarily detrimental to sport, the manner in which it is achieved could be. For athletes seeking to alter their body composition by losing weight, the suggested rate is no more than one percent of their body weight per week (Garthe, Raastad, Refsnes, et al., 2011). This rate allows athletes to better maintain lean muscle mass, which is relevant for sport. Moreover, athletes seeking to change body composition through dietary intakes should be monitored and supported by those around them, such as by teammates, coaches, and athletic trainers.

## Trends in Dietary Intakes

While some nutrients are consumed in adequate amounts for female athletes, a trend is apparent in those that are not. In a 2004 study, Hinton et al. examined the trends and tendencies of collegiate athletes in regard to dietary intakes. The results from the study suggest that the average EI for females was appropriate for light-to-moderate activity, but not for highly active athletes. The majority of males and females in their study were also consuming inadequate amounts of carbohydrates and protein.

These results are similar to those found by Nepocatych, Balilionis, and O'Neal (2017). Division I female athletes from softball and basketball were assessed for dietary intakes using 3-day food records, and physical activity over the course of a season. The results showed deficiencies in caloric intake, indicating that female athletes were performing with low energy levels. With the same regard, the athletes in the study on average consumed inadequate amounts of carbohydrates and multiple micronutrients (vitamin A, vitamin E, calcium, magnesium, iron, and potassium). Consumptions were also in the low range of the recommended minimum for protein, while fat intakes were acceptable. These studies demonstrate the trend of inadequate caloric intakes among female collegiate athletes, as well as the inadequate intakes of carbohydrates and protein. Over time, inadequate fueling for activity could lead to unfavorable changes in body composition and puts the athlete at risk for developing injuries (Rauh et al., 2010).

## Depth of Nutritional Knowledge

Previous literature has consistently shown that both male and female collegiate athletes score poorly on nutritional knowledge questionnaires, perhaps causing the observed insufficient consumption of optimum nutrients required for performing well in their sport (Cholewa et al., 2015; Dunn et al., 2007; Hinton et al., 2004; Hornstrom et al., 2011; Jonnalagadda et al., 2001; Nepocatych et al., 2017; Rosenbloom et al., 2002; Rossi et al., 2017; Torres-McGehee et al., 2012; Valliant et al., 2012).

A 2007 study by Dunn et al. highlights this trend. The researchers assessed collegiate athletes' nutritional knowledge in relation to recommended requirements and their attitudes towards healthy eating. The participants were recruited from a variety of sports clubs (e.g., football, volleyball, softball). It was hypothesized that nutritional knowledge would be low, but that healthy eating attitudes would be high. The results from their study showed that the eating attitudes of the athletes were positive, with only 5.8% of participants scoring 'not at-risk' for attitudes suggesting an eating disorder. On the nutritional knowledge assessment, participants answered an average of 51% of the questions correctly. The results from this study echo the findings and conclusions from other research, wherein the scores on the surveys indicate that collegiate athletes could benefit from implemented nutritional education, as they perceived healthy nutrition positively.

## Sources of Information for Nutritional Knowledge

Student-athletes agree that accurate nutritional knowledge is the "best way to achieve favorable changes in food habits," (Zawila et al., 2003, p. 69). Attaining sport nutrition knowledge that will help achieve peak performance is known to be a desire among athletes (Jonnalagadda et al., 2001). However, access to accurate nutritional knowledge is not consistent among NCAA sports teams, leaving student-athletes at risk for misinformation in sport nutrition. While the collegiate sports program is responsible for providing resources for athletes' well-being and educational success, a gray area exists between the university and athletic departments about who provides nutrition education (Karpinski, 2012). Due to this inconsistency, many athletes resort to seeking nutritional information from a variety of sources on their own, and are likely to find conflicting information. Additionally, this information may not be specifically geared towards athletes or performance in their individual sport. Sources of information include coaches, parents, athletic trainers (ATs), strength and conditioning specialists (SCSs), teammates, and media (Hornstrom et al., 2011; Rosenbloom et al., 2002; Zawila et al., 2003). The accuracy and depth of knowledge athletes receive is limited by the knowledge and information held by these sources.

An investigation by Torres-McGehee et al. (2012) sought to identify the resources used by collegiate athletes to obtain nutritional information, and examine the knowledge among athletes, coaches, ATs, and SCSs from NCAA Division I, II, and II universities. Participants completed a validated sport nutrition knowledge questionnaire that assessed their nutritional knowledge, including information on macronutrients, micronutrients, and hydration. Results from the study showed an average of 68.5% of all questions answered correctly by all participants. ATs (77.8%) and SCSs (81.6%) scored higher on the knowledge test than coaches (65.9%) and athletes (54.9%), which is in line with previous research. However, it was suggested that even ATs and SCSs should consult or refer athletes to registered dietitians (RDs) or other nutritional experts when the needs of the athlete are beyond their scope of practice. The results from this investigation suggest that currently, those involved with athletes have an overall gap in sport nutrition knowledge, and that athletes and coaches could benefit from receiving proper nutritional education related to their sport. This study also highlights the importance of an RD, which is not accessible by all sports teams.

To examine the effect of an RD on nutritional knowledge, Rosenbloom et al. (2002) investigated the nutritional knowledge of NCAA Division I student athletes using a self-administered nutritional knowledge questionnaire. The student athletes at the researchers' institution had access to an RD who conducted team and individual counseling for athletes - a practice not commonly reported for other institutions. The authors concluded that collegiate athletes were generally aware that dietary habits could influence performance, and based on low scores, could benefit from additional sport nutrition education despite having regular access to an RD.

The results from these studies further support the findings from Zawila et al. (2003), which indicated that the source of nutrition information and number of sources used by athletes showed no correlation with nutritional knowledge on knowledge questionnaires. The overall results from these studies suggest that when athletes are tasked with seeking nutritional information individually, they fall short of acquiring information necessary to help them optimize performance from a nutritional standpoint.

## Nutritional Knowledge and Dietary Habits

Although favorable body composition, as achieved through proper nutrition and training, plays a notable role in sports performance, it cannot be assumed that better nutritional knowledge will translate into better dietary habits or performance. Some studies have found that nutritional knowledge does translate into practice. Hornstrom et al. (2011) found that there was a positive correlation between the scores on a sport nutrition knowledge questionnaire and eating habits. Collegiate softball players who scored well on the questionnaire practiced significantly better dietary habits than those who scored lower.

However, other studies did not find the same relationship between knowledge and translation into practice. For example, Rossi et al. (2015) had Division I NCAA female athletes complete a sport nutrition questionnaire, three-day dietary intake food journal, body composition test, and a vertical jump. The results from their investigation showed that nutritional knowledge did not have a relationship with the athletes' body compositions, dietary intakes, or power as assessed from the vertical jump. Similarly, a 2015 study by Alaunyte et al. investigated the relationship between nutritional knowledge and nutritional habits in professional rugby players. Results from their study indicated that athletes had adequate nutritional knowledge, but were not meeting the requirements for carbohydrate intake. Those who scored well on the assessment consumed more fruits, vegetables, and carbohydrate-rich foods, but not other categories of food, meaning that there was a general lack of translation of knowledge into practice, and that a relationship to performance could not be established.

The same tenet is also true regarding hydration practices. One-third of surveyed athletes scored below 80% on the hydration knowledge questionnaire as investigated by Nichols et al. (2005). While many athletes showed they had adequate knowledge and positive attitudes about hydration in sport, there was not a consistent translation into applying their knowledge.

Additionally, changes in dietary behaviors resulting from SNEIs should be interpreted with caution, as not all changes are positive. Siti et al. (2018) saw changes in dietary intakes among team sports participants after their seven-week SNEI. Total caloric intakes were increased, which were deemed positive changes. However, participants in the experimental group experienced a reduction of percentage of calories from carbohydrates in their diet at posttest, which was already below the RDI at pretest. They also were consuming more than the RDI for protein, despite keeping the percentage of protein intake the same.

Several reasons exist for why higher nutritional knowledge may not translate into practice consistently, particularly with collegiate athletes. Some of these reasons include higher nutrient requirements for athletes or purposefully restricting diet to lose or maintain weight for sport. Additionally, college student athletes have unique schedules and access to food. They may be limited in times they can dedicate to food preparation and eating, and their dietary choices may be limited by dining hall offerings or access to grocery stores (Hornstrom et al., 2011; Zawila et al., 2003). Also, comparing results from these studies is difficult due to the inconsistent use of sporting disciplines, small sample sizes, diversity of participants, and heterogeneity of methods and instruments used (Trakman et al., 2016). These studies also assess the relationship of existing nutritional knowledge and dietary practices, and do not seek to examine how dietary practices may change following changes in nutritional knowledge.

## Nutritional Knowledge, Body Composition, and Performance

Despite conflicting research on translation of nutritional knowledge into better dietary habits, it is still logical that increased nutritional knowledge could lead to changes in body composition through changes in eating. One way to assess the effects of nutritional knowledge on body composition is through structured nutrition education interventions. These structured interventions allow for insight to how dietary practices, body compositions, and performance may change in relation to a change in nutritional knowledge. As expected, SNEIs improve nutritional knowledge in athletes (Abood et al., 2004; Chapman et al., 1997; Cholewa et al., 2015; Collison et al., 1996; Doyle-Lucas & Davy, 2011; Martinelli, 2013; Nascimento et al., 2016; Patton-Lopez et al., 2018; Rossi et al., 2017; Siti et al., 2018; Tam et al., 2019; Valliant et al., 2012; Yannakoulia et al., 2002). However, there are conflicting results on whether this translates into physical changes in body composition through dietary intake.

A study by Garthe, Raastad, and Sundgot-Borgen (2011) examined elite athletes trying to gain lean mass over an eight- to ten-week off-season resistance-training period. During the intervention, body mass increased more participants who received individualized nutritional counseling. For athletes who received nutritional counseling, body mass, specifically lean body mass, was significantly higher at both the six- and 12-month check-ins compared to the control. Lean body mass is important for power-related sports, as more lean body mass typically equates to the production of more power and increases in performance. The results from the study suggest that nutritional counseling can lead to changes in dietary habits that induce body composition changes that align with athletes' goals for performance.

Similarly, a study on NCAA Division I baseball players specifically examined the effects of an SNEI on sport nutrition knowledge, body composition, and performance (Rossi et al., 2017). Pre-offseason and post-offseason measures were assessed in an intervention group, who received 180-minutes of nutritional education (1 90-minute, 3-45 minute sessions), and a control group. The measures assessed included sport nutrition knowledge, body composition, 3-day dietary food logs, and measures of physical performance (5-10-5 shuttle test, vertical jump, broad jump, 1RM back squat). Results from the study showed significant decreases in body fat percentage and fat mass in the intervention group compared to the control group. Additionally, the intervention group increased their 5-10-5 shuttle times and experienced greater increases in lean mass compared to the control. Rossi and colleagues' study supports that implementation of nutritional education can further enhance body composition and subsequently performance through improved dietary habits. Few others have examined the effect of an SNEI on body composition in athletes and found improvements (Buffington et al., 2016; Nascimento et al., 2016).

Despite these findings, the effect of increased nutritional knowledge on body composition is not researched extensively in athletic populations. However, other populations have been investigated. A study by Matvienko et al. (2001) investigated if a nutrition course, focused on tenets of "human physiology, energy metabolism, and genetics" would cause a significant difference in the amount of weight gained by female college students over 16 months. Students were assigned to a control group or an intervention group, with the intervention group receiving one semester (four months) of a class that focused on the previously mentioned tenets. The course was not designed for weight loss, but rather to provide scientific information to help guide nutritional habits and prevent weight gain. Both groups completed pre-, post-, and one-year retention nutritional knowledge tests. As expected, the intervention group scored significantly higher than the control group on the posttest. To further analyze results, the researches divided the groups into those with desirable BMIs and those with higher than desirable BMIs. The desirable BMI participants in the intervention group experienced no significant changes in dietary habits, weight, or BMI compared to the control group. However, the findings from the knowledge test translated into practice for the high BMI group, wherein participants in the intervention group were found to consume less kcals per day compared to the control group at the end of the intervention.

Although results from these studies support that nutritional knowledge can effectively be translated into better dietary habits, favorable body composition, and ultimately performance, other studies suggest otherwise. For example, Folasire et al. (2015) found that higher nutritional knowledge or better dietary habits in undergraduate student athletes did not correlate positively with handgrip strength, where handgrip strength was the measure of athletic performance. However, this may not be the most representative measure of performance.

Similar to studies that examine the relationship between nutritional knowledge and dietary habits, comparing results from studies on changes in nutritional knowledge, dietary habits, body composition, and performance is difficult due to the inconsistent use of sporting disciplines, small sample sizes, diversity of participants, and heterogeneity of methods and instruments used (Tam et al., 2019). The conflicting conclusions on translation into practice found in the literature could suggest that other variables are exerting influence in successful translation, such as from psychological ideologies.

## Social Cognitive Theory and Self-Efficacy

Bandura's Social Cognitive Theory (SCT) describes how personal experiences, interactions with others, and interactions with the environment influence human learning (LaMorte, 2018). One component of SCT is perceived self-efficacy, which is defined as, "conviction that one can successfully execute the behavior required to produce outcomes," (Bandura, 1977, p. 193). Generally, the decisions that an individual makes about the activities they invest their time in can be attributed to their individual levels of perceived self-efficacy. Those who exhibit high perceived self-efficacy tend to engage in more difficult tasks, remain persistent in difficult activities, and recover more quickly after a setback as compared to those who exhibit low perceived self-efficacy. Within Bandura's theory of self-efficacy are four fundamental principles of how self-efficacy can be developed.

### Performance Accomplishments

This source of self-efficacy, often called "mastery experiences", is considered to be most influential. It is based on the individual experiencing success in their tasks and activities. Several strategies exist to provide individuals opportunities for success, such as scaling difficult tasks or setting realistic goals for change (Cox, 2012). The timing of performance accomplishments should also be considered. If early attempts are successful, individuals build stronger self-efficacies that can withstand later setbacks or failures. If failure is experienced early, self-efficacy is hindered and the individual may not continue to pursue the task (Bandura, 1977).

Vicarious Experiences

Vicarious experiences allow individuals to set expectations for success based on performances of others. Individuals can gain self-efficacy by watching others similar to themselves be successful in an activity, or lose self-efficacy from observing failures. However, individuals can also learn from the failures of others, increasing self-efficacy. The main strategy to build self-efficacy through vicarious experiences is to observe demonstrations by others (Bandura, 1977; Cox, 2012).

Verbal Persuasion

Others can increase self-efficacy through use of verbal persuasion. It is used positively to persuade individuals that they are capable of completing the task successfully, or negatively to persuade them that they do not have the skills to accomplish the task. Self-efficacy tends to increases less substantially through verbal persuasion alone as compared to other principles. This is due to incorporation of experiences in past performances, which may contradict what others are telling them. However, when verbal persuasion is coupled with strategies from other principles, such as scaled-tasks, individual efforts to be successful increase, resulting in improved self-efficacy (Bandura, 1977). Self-persuasion can also be used, wherein athletes can use positive self-talk to build confidence or as encouragement to complete the task (Cox, 2012).

Emotional Arousal

Individuals experience different cognitive and physiological states dependent on the task that can influence their success. Specifically, individuals experience various levels of arousal. The individual bases the outcome of the task mainly on the perception of the arousal. Those with high self-efficacy tend to use arousal as an energizing factor, whereas those with lower self-efficacy view arousal as hindering (Bandura, 1977). Strategies to improve self-efficacy through emotional arousal include reframing negative thoughts or developing pre-performance routines to ease anxiety (Cox, 2012).

## Self-Efficacy and Intention

Physical changes may not be the only change associated with nutritional knowledge. Previous investigations on nutrition education interventions show conflicting translation into practice, suggesting that there may be a contributing factor from underlying psychological concepts, such as self-efficacy. Research with nonathletes has shown that self-efficacy is an important contributor in dietary habits (Anderson et al., 2007; Poddar et al., 2010). However, research on nutritional self-efficacy among collegiate athletes, particularly as it relates to SNEIs, is scant. Existing literature on self-efficacy among collegiate athletes shows an average score of 70% on self-efficacy measurements, suggesting a general lack of confidence in making nutritional choices (Abood et al., 2004; Bolles, 2008; Karpinski, 2011).

However, research suggests that exposure to nutrition information, regardless of delivery method, can increase self-efficacy. Karpinski (2011) investigated changes in nutritional self-efficacy among an experimental group receiving an interactive web-based SNEI, and a control group receiving static articles on nutrition. Both groups experienced an increase in self-efficacy after the research period, and did not score significantly different from each other on self-efficacy measurements. These results confirm trends seen in earlier studies. Abood et al. (2004) measured the changes in nutritional self-efficacy after an SNEI in volleyball players. Throughout the SNEI with their experimental group, self-efficacy was addressed, such as providing athletes opportunities to be successful in making healthy dietary choices. At posttest, athletes in the experimental group showed a significant increase in self-efficacy related to nutrition as compared to the control group. Similarly, Bolles (2008) found that the experimental group self-efficacy in collegiate athletes after an SNEI was significantly increased as compared to the control group. These studies collectively suggest that increases in nutritional knowledge have a positive impact on nutritional self-efficacy in collegiate athletes.

The explicit relationship between changes in nutritional knowledge and nutritional self-efficacy from these studies is not clear, as the data was not analyzed with regard to growth in nutritional knowledge. However, more research in this area is needed in athletes, as increases in self-efficacy are known precursors to behavioral changes, which may include dietary habits (Abood et al., 2004). Understanding how self-efficacy changes in relation to nutritional knowledge may guide more comprehensive planning for improving sports performance over time. In order to successfully examine these relationships, SNEI structure should be based on research-supported concepts.

## Learning and Retention

Previous methodologies used in investigating SNEIs and their effects use various structures in timing and delivery. Of the literature reviewed, the methods included face-to-face instruction, web-based learning, and various lengths of intervention. Few studies tested for retention after the posttest. However, retention is the primary purpose of education, and is vital in achieving related long-term goals, such as body composition changes and subsequent performance. Therefore, the structure of an SNEI should incorporate principles that increase storage of information, and retrieval of that information through time.

One way to enhance long-term retention of knowledge is to vary the way in which the content is delivered. The primary two models for delivery of content are mass delivery and dispersed delivery (Raman et al., 2010). In mass delivery, content is disseminated on a one-time basis. This method is useful when time constraints are present or the amount of information presented is minimal. However, previous research has shown that dispersing content over a longer period of time in smaller portions can lead to increased long-term retention when the amount of content to be delivered is substantial. This is considered due to limitations in working memory as outlined in the Cognitive Load Theory (Sweller, Van Merrienboer, & Paas, 1998).

Cognitive load is how much information the working memory is dealing with at a given instance in time. This means that the working memory can only hold a limited amount of information that will eventually be encoded into long-term knowledge (Sweller et al., 1998). The number of items the working memory can tolerate is widely accepted to be seven (Miller, 1956). Additionally, the number of items able to be actively processed by the working memory, not just recalled or held on to, is considered two or three. This information has implications for how new knowledge is delivered to learners. Any piece of knowledge over three that the instructor asks a learner to process, or over seven that the instructor asks a learner to hold on to, will likely not make it into long-term storage where capacity is considered unlimited. Based on this tenet of the Cognitive Load theory, the mode for delivery of information becomes relevant. If long-term retrieval of the knowledge is the end goal, then the information should be presented in a manner that allows the learner enough working memory capacity to transfer the knowledge into long-term storage. Additionally, working memory capacity is limited by fatigue (Raman et al., 2010). When considering mass delivery or dispersed learning, knowledge with multiple facets should be presented over a dispersed period of time to maximize working memory capacity, and avoid lowering this capacity through the fatigue often associated with mass delivery sessions.

Raman et al. (2010) demonstrated how dispersing content over a period of time improves long-term knowledge retention. In their study, they delivered the same nutritional knowledge to two separate groups: one in a single, four-hour session, and one in four weekly one-hour sessions. The results from their study showed that short-term knowledge for all participants was enhanced, but those who received dispersed delivery performed significantly higher on both the post test and the three-week retention test. The results were contributed to the cognitive load theory, in that the dispersed delivery participants had reduced cognitive load and therefore were able to transfer more information from working memory into long-term storage for later recall.

Few studies have assessed sport nutrition knowledge beyond the immediate posttest of the study in athletes. Collison et al. (1996) used a three-month period after a nutrition education intervention to test retention in collegiate female athletes. In both

Collison and colleagues' study and others', nutritional knowledge at the retention test was significantly higher than at pretest, and not significantly different than at the posttest, suggesting that knowledge was retained (Doyle-Lucas & Davy, 2011); yet others have noted an apparent decline in retention of nutritional knowledge after the posttest (Yannakoulia et al., 2002), suggesting a potential need to supplement knowledge over time.

Translation into practice after the intervention was only assessed in two identified studies on athletic populations. Doyle-Lucas and Davy (2011) concluded that dietary habits in dancers declined at retention compared to posttest, but were still significantly higher than baseline, while Yannakoulia and colleagues (2002) concluded that dietary behaviors (e.g., dieting, food preoccupation) were decreased after intervention, but nutrient intakes were unchanged. Although scarce with athletes, the effects of a nutrition knowledge intervention over time have also been studied in other populations that may provide more insight as to how dietary behaviors may be influenced after nutrition education.

Brink and Sobal (1994) studied the impact of a nutrition education program on participants from low-income families. At graduation, participants scored significantly higher on nutritional knowledge tests, and had decreased the percentage of calories from fat in their diets. Additionally, a study by Matvienko et al. (2001) investigated if a nutrition course would cause a significant difference in the amount of weight gained by female college students over 16 months. Participants in the education intervention group consumed fewer calories per day compared to the control group at the end of the intervention. These differences, however, were not found to be significant at the one-year check-in, and participants in the intervention group showed a decline in retention of nutritional knowledge from posttest. These results show that a short-term nutritional knowledge intervention using dispersed delivery could translate into long-term changes, but may need to be reviewed over time for continued results.

Lastly, the changes in self-efficacy associated with increased nutritional knowledge are not well researched in athletes. Of the few studies on self-efficacy post-intervention in athletic populations, only one identified study examined self-efficacy specifically after the intervention period (Doyle-Lucas & Davy, 2011). At six-weeks post intervention, Doyle-Lucas and Davy reported a decline in self-efficacy in dancers. More research on how self-efficacy persists after intervention may provide insight on the changes or lack of change in dietary habits following intervention.

## Conclusion

The proposed study examines the influence of an SNEI on nutritional knowledge, dietary habits, self-efficacy, body composition, and performance. From the literature reviewed, it is clear that collegiate athletes score low on nutritional knowledge tests despite viewing nutrition favorably and having access to a variety of sources. Additionally, collegiate athletes consistently consume diets that are less than ideal for optimal sport performance. It is also evident that SNEIs improve nutritional knowledge.

However, the literature presents conflicting results on the translation of nutritional knowledge into better dietary habits, more favorable body compositions, or increased performance. A potential underlying factor in this lack of translation could be from psychological concepts, such as self-efficacy. However, there is limited research on how self-efficacy is influenced by nutrition education, especially after the intervention period. Moreover, the design of SNEIs in the literature is heterogeneous, wherein comparison between studies could be more plausible if based on established educational constructs. Lastly, relatively few studies have examined the effects of an SNEI in Division I female softball players, justifying the need for an intervention with the present population.

# CHAPTER III

# METHODS

## Participants

Twenty-two Division I softball players were invited to participate in the study in-person by the researcher. The inclusion criterion was that they were required to be members of the 2019-2020 team at the University of Northern Iowa. The researcher met with potential participants following a team-scheduled meeting, and informed the potential participants of the purposes and logistics involved in the study. While the team's coaches were asked to encourage athletes to participate voluntarily, coaches were not present at any point in the investigation to protect against participation bias.

Of the 22 invited participants, 11 returned the contact information form. Ten participants attended the first scheduled meeting and completed the informed consent. Three participants did not complete the entirety of the investigation due to time constraints, a severe injury, and withdrawing from the team. Thus, seven participants completed the entirety of the investigation.

## Instrumentation

### Demographics

Participants completed a 13-question demographics survey. The participants completed 9 of the 13 questions once at the beginning of the intervention. These included questions pertaining to age, ethnicity, year in school, and where they live during the school year. Additionally, participants were asked about their prior experience with nutrition education, if they attended a sport nutrition talk or course in the previous 12 months, and what sources they use for sport nutrition knowledge. The participants completed 4 questions in the demographics portion of the questionnaire each time it was administered (three times for intervention group, four times for control group). These included questions about current playing restrictions, self-rating of sport nutrition knowledge, how much attention they give to nutrition, and body composition goals.

<u>Sport Nutrition Knowledge Questionnaire</u>

Sport nutrition knowledge and dietary habits were assessed using a modified version of the Reilly and Maughan *Dietary Behaviors and Nutrition Knowledge Questionnaire* (DBNK; 2007). The questionnaire has a test-retest Pearson correlation coefficient of .91. Permission to use the questionnaire was granted by the author. The original questionnaire is divided into 10 subsections that address various sport nutrition topics. Subsections include: demographics, diet pattern (i.e., dietary habits), hydration, weight control, dietary supplements, general nutrition, sport nutrition, protein, strategies for training and food choices, and a section on nutrition specifically for swimmers. The demographics were modified to accommodate the needs of the present study and contained 13 questions. The swimmer-specific section was dropped in light of the present population, and the open-ended questions were omitted to improve reliability, as done in a similar study (Rossi et al., 2017).

The modified survey consisted of 77 questions in 9 subsections (Appendix A). Participants answered 8 dietary habits questions that were scored as 1 point for favorable or 0 points for unfavorable. One was scored from 1 to 5 based on response, making the total possible for dietary habits 15 points. Other answers in the dietary habits were analyzed descriptively and not scored. Participant answers to questions in all following subsections (i.e., hydration, weight control, dietary supplements, general nutrition, sport nutrition, protein, strategies for training and food choices) were given a score of one if correct and zero if incorrect, making the range of possible scores for nutritional knowledge 0 to 49 points.

## Nutritional Self-Efficacy

Nutritional self-efficacy was assessed using the *Self-Efficacy Questionnaire* (SEQ) developed and validated by Abood et al. (2004). The instrument achieved a .86 Pearson correlation value on test-retest reliability. Permission to use the questionnaire was granted by the author. The questionnaire consisted of 10 questions on 5-point Likert scale (Appendix B). Response options ranged from 1 ("not confident at all") to 5 ("extremely confident"). Example statements included "I am able to eat enough calories every day" and "I can eat the right proportion of carbohydrates, fats, and protein on a daily basis." The range of possible scores in nutritional self-efficacy was 10 to 50.

## Nutritional Intentions

Intention to change has been shown to be the most important predictor of behavioral change, as outlined in the Theory of Planned Behavior (Pawlak et al., 2009). Behavioral intention is the resolve to perform a behavior, such as eating a diet that reflects proper recommendations for sport. To ensure that participants' were putting forth effort in fueling properly for sport as based on information from the education sessions, participants' intentions to eat a healthy diet were measured using established statements modified from the *Collegiate Athlete Survey of Nutritional Diets* (Pawlak et al., 2009).

The four items selected from the survey measured behavioral intention (Cronbach's $\alpha = .90$) and were modified to assess nutritional intentions for the upcoming week and/or from the previous week (Appendix C). Four future intention items included statements such as "I intend to eat a diet to help me perform at my best" and "I will try eating a healthy diet to help me perform at my best." Three reflective intention items included items such as "Since our last meeting, I ate a healthy diet that would help me perform at my best" and "I thought about changing my regular eating habits based on information from the education session(s)." All statements were scored on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The future intentions survey was administered to participants five times at the end of each content knowledge session. The reflective intention survey was administered six times: at the beginning of the second, third, fourth, and fifth content knowledge session, posttest, and retention test. The mean scores for each week's reflective and future intentions items were used in analysis consistent with the scoring method used in the design of the survey.

Body Composition

Body composition was assessed via BodPod (Life Measurement Inc., Concord, CA, USA) in the exercise physiology lab on campus. Measures of interest recorded during the assessment included percent body fat, percent fat-free mass, fat mass (lb), fat-free mass (lb), and body mass (lb). Masses in pounds were converted to kilograms for analysis. Participants were instructed to follow several guidelines prior to completing body composition measurement via BodPod at the first scheduled meeting and were provided a written copy of the guidelines. These guidelines included refraining from food, drink, and exercise for at least 3 hours prior, emptying bowels, refraining from using lotions or skin creams, and removing glasses and jewelry. Additionally, participants were asked to wear minimal, skin-tight clothing, such as sports bras and spandex-like shorts, and to wear the same or similar clothing in subsequent measurements. Participants were not provided the results from their BodPod assessment until after the completion of the entire investigation. Height was taken once at the first measurement session using an adult Shorrboard (Weigh and Measure, LLC, Olney, MD, USA).

Exit Velocity

Exit velocity data was attained from the team coaches at regular practice times. The data was recorded using Rapsodo Hitting 2.0 (Rapsodo Pte. Ltd., Singapore). Participants were instructed to swing as hard as they could for ten swings, and their highest exit velocity was recorded. To protect participants' anonymity, all players' data was acquired, and then the data that corresponded to the participants was extracted. These measures were completed during each week of testing (i.e., weeks 1, 7, 10, 13, and 16).

Sport Nutrition Education Intervention (SNEI)

The SNEI was structured based on tenets of Cognitive Load Theory (Sweller et al., 1998), wherein three to seven main ideas were relayed to participants per session. Each education session lasted approximately 30-60 minutes and were conducted face-to-face by the researcher in a classroom at the softball hitting facility using PowerPoint on a large screen. During each session, the researcher provided nutrition information, followed by activities for participants to practice applying their knowledge, as suggested by self-efficacy theory (Bandura, 1977). For example, after instruction from the researcher about macronutrients, participants were assisted in calculating their individual macronutrient needs. Each session ended with the opportunity for participant to ask questions.

## Procedures

All procedures were approved by the Institutional Review Board prior to beginning the investigation. The length of the investigation spanned 16 weeks (Table 1). At the first meeting, logistics of the study were discussed and contact information forms were provided for those interested in participating. In a second meeting in week 1, all participants completed informed consent forms and the demographics survey, the DBNK, and SEQ, and exit velocity measures were obtained from the softball coaches. These were baseline measures. Participants signed up for a time to have their body composition assessed within one week. Participants were assigned randomly to one of two groups. The intervention group received the content knowledge sessions first, while control group did not.

The content knowledge sessions occurred weekly and covered a different topic related to sport nutrition (i.e., carbohydrates, protein, fat, micronutrients, hydration, and timing). Intention surveys were also administered. In week seven, all participants completed the DBNK, SEQ, and body composition measurement, and exit velocity measurements were obtained from coaches. The control group then completed the content knowledge sessions after serving as the control, and the same posttest measurements as completed by the intervention group.

The intervention group participants completed retention tests consisting of the DBNK, SEQ, and body composition measurement, and exit velocity measures were obtained from coaches three weeks after taking the posttest. The control group also completed retention test measures three weeks after taking their posttests that followed their intervention.

Table 1

*Data Collection Timeline*

| Week(s) | Tasks |
|---|---|
| 1 | Invitation to participate, informed consent forms, Pretests (All groups): Demographics, DBNK, SEQ, BC, EV |
| 2-6 | IG content knowledge sessions: |
| 7 | IG & CG end of control period: Demographics, DBNK, SEQ, BC, EV |
| 8-13 | CG content knowledge sessions |
| 10 | IG retention test: Demographics, DBNK, SEQ, BC, EV |
| 13 | CG posttest: Demographics, DBNK, SEQ, BC, EV |
| 16 | CG retention test: Demographics, DBNK, SEQ, BC, EV |

*Note.* IG = Intervention group. CG = Control group. DBNK = Dietary Behaviors and Nutritional Knowledge Questionnaire. SEQ = Self-Efficacy Questionnaire. BC = Body composition. EV = Exit velocity.

## Data Analyses

Two-way mixed ANOVAs were used to determine if the intervention group scored higher in nutritional knowledge, self-efficacy, and dietary behaviors, and improved in favorable body composition and exit velocity as compared to the control group from baseline to the end of the control period. Bonferonni post hoc analyses were used to determine specific differences in nutritional knowledge, dietary behaviors, self-efficacy, body composition, and exit velocity between intervention and control groups at all time points, as well as the change from one time point to another. This method was also used for measuring reflective and future intentions throughout the intervention. One-way repeated measures ANOVAs with Bonferonni post hoc analyses were used to ascertain if there were improvements in nutritional knowledge, self-efficacy, dietary behaviors, body composition, and exit velocity from pretest to posttest to retention. The alpha level for all analyses was set at 0.05. Analyses were conducted using IBM SPSS Statistics 24 (IBM Corp., Armonk, NY, USA).

# CHAPTER IV

# RESULTS

## Participant Anthropometrics

The participants' anthropometric characteristics were completed at baseline testing, as shown in Table 2. The age range for participants was 18 to 21 years old (19.67 ± 1.52). When placed into groups, the intervention group (*n* = 4) age range was 18 to 21 years (20.14 ± 1.21) and the control group's (*n* = 3) range was 19 to 21 years (20.50 ± 1.0). Participants' overall mean height (*n* = 7) was 170.60 ± 1.94 centimeters.

The intervention group had an average of mass of 71.63kg ± 8.04kg, while the control group had a mean weight of 68.44kg ± 7.57kg. The average mass of the sample was 75.88kg ± 7.79kg.

Table 2

*Demographic Anthropometrics at Baseline*

| | Intervention (*n* = 4) | | Control (*n* = 3) | | Total (*n* = 7) | |
|---|---|---|---|---|---|---|
| Variable | *M* ± *SD* | Range | *M* ± *SD* | Range | *M* ± *SD* | Range |
| Age (years) | 20.14 ± 1.21 | 18 - 21 | 20.50 ± 1.0 | 19 - 21 | 19.67 ± 1.52 | 18 - 21 |
| Height (cm) | 166.55 ± 4.78 | 158.75 – 172.72 | 163.51 ± 3.79 | 158.75 – 167.64 | 170.60 ± 1.94 | 168.91 – 172.72 |
| Mass (kg) | 71.63 ± 8.04 | 60.85 – 82.29 | 68.44 ± 7.57 | 60.85 – 78.37 | 75.88 ± 7.79 | 67.21 – 82.29 |

*Note*. *M* = Mean. *SD* = Standard Deviation.

## Participant Characteristics

Demographic characteristics were measured only during the baseline test except for one question regarding playing and/or practice restrictions. The majority of participants were seniors by both academic status and athletic eligibility ($n$ = 4). Of the seven participants, two marked their residence as "on campus" during the school year, as well as having a full meal plan provided by the university. Six of the participants reported not attending a sport nutrition class or talk within the last twelve months, as well as not having access to an RD or nutritionist. Lastly, participants were asked to rank their top five sources for nutrition information from a list of ten options (i.e., magazines/popular nutrition books, health food stores/shops, friends/teammates, academic journals/nutrition textbooks, media/internet, sports dietitian/nutritionist, doctor/nurse, parents/family, sports workshops/courses, and coach/trainer). The main sources as indicated by the participants are shown in Table 3 with other demographic responses. Lastly, one participant indicated limited playing and/or practice restrictions throughout the investigation.

Table 3

*Demographic Characteristics*

| Variable | Intervention (*n* = 4) | Control (*n* = 3) | Total (*n* = 7) |
|---|---|---|---|
| | *n* (%) | *n (%)* | *n* (%) |
| Ethnicity | | | |
| White | 4 (100) | 3 (100) | 7 (100) |
| Year in school | | | |
| Freshman | 1 (25.0) | 1 (33.3) | 2 (28.6) |
| Junior | 0 (0) | 1 (33.3) | 1 (14.3) |
| Senior | 3 (75.0) | 1 (33.3) | 4 (57.1) |
| Athletic Eligibility | | | |
| Freshman | 1 (25.0) | 1 (33.3) | 2 (28.6) |
| Junior | 0 (0) | 1 (33.3) | 1 (14.3) |
| Senior | 3 (75.0) | 1 (33.3) | 4 (57.1) |
| Practice / playing restrictions | | | |
| None | 3 (75.0) | 3 (100) | 6 (85.7) |
| Limited participation | 1 (25.0) | 0 (0) | 1 (14.3) |
| Residence during school year | | | |
| On campus | 1 (25.0) | 1 (33.3) | 2 (28.6) |
| Off campus | 3 (75.0) | 2 (66.7) | 5 (71.4) |
| Campus meal plan | | | |
| Yes | 1 (25.0) | 1 (33.3) | 2 (28.6) |
| No | 3 (75.0) | 2 (66.7) | 5 (71.4) |
| Sport nutrition class within last 12 months | | | |
| Yes | 1 (25.0) | 0 (0) | 1 (14.3) |
| No | 3 (75.0) | 3 (100) | 6 (85.7) |
| Access to RD/nutritionist | | | |
| Yes | 0 (0) | 1 (33.3) | 1 (14.3) |
| No | 4 (100) | 2 (66.7) | 6 (85.7) |
| Top source for nutrition information[a] | | | |
| Friends / teammates | 2 (50.0) | 0 (0) | 2 (28.6) |
| Parents | 1 (25.0) | 1 (33.3) | 2 (28.6) |
| Media | 1 (25.0) | 1 (33.3) | 2 (28.6) |
| Dietitian | 0 (0) | 1 (33.3) | 1 (14.3) |

*Note.* [a]Participants were asked to rank their top 5 sources for nutrition information from a list of 10 options in order from to 1 (main source) to 5.

Intervention v. Control

Overall Measures

Baseline and end of control period scores for the intervention and control groups from the DBNK and SEQ, body composition measurements, and exit velocity tests are presented in Table 4. The results were analyzed to determine if significant differences existed between the intervention and control groups at baseline or the end of the control period in any measure. Differences between the baseline and end of control period were also analyzed for each measure.

Two-way 2 (time: baseline or end of control) x 2 (group: intervention or control) mixed ANOVAs were conducted to examine the effects of group and time on each measurement. The test of within-subjects revealed that nutritional knowledge was significantly different over time, $F(1, 5) = 44.633$, $p = .001$), and for group x time, $F(1, 5) = 22.102$, $p = .005$. Post hoc analyses using Bonferonni correction showed no significance between groups, times, or group x time. Due to the small sample size, a Tukey correction analysis was conducted to understand where significance might occur should the trends continue as based on plots. The Tukey post hoc correction analysis showed the intervention group experienced a significant increase in nutritional knowledge scores from baseline to end of the control period, as well as a significant difference in these scores between the intervention group and control group at the end of the control period.

There was a significant interaction for dietary behaviors over time, $F(1,5) = 12.717$, $p = .016$. Post hoc analyses with Bonferonni correction showed no significant interactions, likely due to lack of statistical power. However, a post hoc analysis using Tukey corrections showed that there was a significant increase in dietary behaviors in the intervention group from baseline to the end of control period. Additionally, plots suggest that with a larger sample, it is likely a significant increase in dietary behaviors after intervention may occur.

No significant interactions occurred for body fat, fat free mass, or exit velocity. These results indicate that for these measures, despite some changes, no significant differences existed between groups at either time point, nor over time. Participants did not score differently on these measures over time regardless of completing an SNEI.

However, there were significant interactions for group x time for self-efficacy, $F(1, 5) = 9.581$, $p = .019$. No significant differences between groups over time or at the same time points were found in the post hoc analyses. This is likely due to a lack of statistical power. Based on the results and plot trends, the intervention group had increases in self-efficacy from baseline to the end of the control period, and the control group had decreases in self-efficacy over the same time period.

Table 4

*Intervention and Control Group Scores from Baseline to End of Control Period*

| Measure | Intervention (*n* = 4) | | Control (*n* = 3) | |
|---|---|---|---|---|
| | Baseline | End of Control | Baseline | End of Control |
| | *M* ± *SD* | *M* ± *SD* | *M* ± *SD* | *M* ± *SD* |
| Total Nutritional Knowledge Score[a] | 26.0 ± 3.37 | 37.50 ± 4.65 | 25.67 ± 7.09 | 27.67 ± 8.08 |
| Total Self-Efficacy Score[b] | 26.5 ± 3.87* | 30.5 ± 3.70 | 37.33 ± 8.02* | 28.67 ± 3.21 |
| Total Dietary Behaviors Score[c] | 8.50 ± 1.73 | 9.75 ± 0.50 | 9.0 ± 1.00 | 9.67 ± 0.58 |
| Body Composition - Fat (%) | 21.38 ± 3.65 | 20.8 ± 1.12 | 27.23 ± 6.00 | 26.33 ± 5.61 |
| Body Composition – Fat free mass (kg) | 53.63 ± 3.94 | 53.69 ± 5.20 | 54.93 ± 1.89 | 55.90 ± 1.58 |
| Exit Velocity (mph) | 70.80 ± 5.67 | 67.73 ± 8.60 | 72.77 ±2.54 | 71.07 ± 5.81 |

*Note*. *M* = Mean. *SD* = Standard Deviation. [a] = Out of a possible 49 points. [b] = Out of a possible 50 points. [c] = Out of a possible 15 points. *Significant between groups. Significant at the $p < .05$ level.

Nutrition Subsections

Two-way 2 (time: baseline or end of control period) x 2 (group: intervention or control) mixed ANOVAs were conducted on each nutritional knowledge subsection score. The results are presented in Table 5. No significant interactions occurred between the effects of group and time regarding knowledge in hydration, weight control, general nutrition, sport nutrition, or protein. These results indicate that for these measures, the groups did not differ at baseline or the end of the control period. There were also no significant differences in participants' subsection scores from baseline to the end of the control period.

However, significant changes over time occurred for knowledge in dietary supplements, $F(1, 5) = 14.286$, $p = .013$, and strategies, $F(1, 5) = 19.286$, $p = .007$. There were also significances in group x time interactions for supplements, $F(1,5) = 9.143$, $p = .029$, and strategies, $F(1, 5) = 19.286$, $p = .007$. Post hoc analyses with Bonferonni corrections revealed a significant increase in supplement knowledge in the intervention group from baseline to the end of the control period, $p = .008$. Participants in the intervention group scored higher on supplement knowledge after an SNEI. Significance also occurred between the intervention and control group at the end of the control period, $p = .015$. Participants in the intervention group scored higher in supplement knowledge at the end of intervention as compared to the control group. Despite showing significance for group x time interactions in change of knowledge of strategies, post hoc analyses showed no significant differences. Based on plots, it appears that the trend was the intervention group increased as compared to the control.

Table 5

*Intervention and Control Group Subsection Scores from Baseline to End of Control Period*

| | Intervention ($n$ = 4) | | Control ($n$ = 3) | |
|---|---|---|---|---|
| | Baseline | End of Control | Baseline | End of Control |
| Subsection | $M \pm SD$ | $M \pm SD$ | $M \pm SD$ | $M \pm SD$ |
| Hydration[a] | 4.25 ± 0.96 | 5.50 ± 1.00 | 4.00 ± 1.00 | 4.33 ± 1.53 |
| Weight Control[a] | 4.50 ± 1.29 | 6.00 ± 1.41 | 5.00 ± 1.00 | 5.67 ± 1.53 |
| Dietary Supplements[b] | 2.50 ± 0.58 | 5.50 ± 1.29*** | 2.33 ± 1.15 | 2.67 ± 0.58 |
| General Nutrition[b] | 4.00 ± 1.41 | 5.25 ± 0.96 | 4.00 ± 1.00 | 3.67 ± 2.31 |
| Sport Nutrition[a] | 4.50 ± 1.73 | 6.25 ± 0.50 | 5.00 ± 1.00 | 5.33 ± 1.53 |
| Protein[a] | 4.50 ± 1.29 | 5.75 ± 0.50 | 4.00 ±2.65 | 4.67 ± 1.53 |
| Strategies[c] | 1.75 ± 0.50 | 3.25 ± 0.96* | 1.33 ±1.15 | 1.33 ± 1.15 |

*Note*. *M* = Mean. *SD* = Standard Deviation. [a]Subsection consisted of 7 possible points. [b]Subsection consisted of 8 possible points. [c]Subsection consisted of 5 possible points. *Significant from baseline. **Significant between groups at same time period. Significant at the $p < .05$ level.

Supplement Use

A frequency table was constructed to descriptively analyze dietary supplement use between groups and at different time points (Table 6). The intervention group did not indicate any total frequency changes in dietary supplement use at the end of the control period. The control group indicated minimal changes in dietary supplement use over time.

Table 6

*Supplement Use for Intervention and Control Groups*

| Supplement | Intervention (*n* = 4) | | Control (*n* = 3) | |
|---|---|---|---|---|
| | Baseline | End of Control | Baseline | End of Control |
| | *n* (%) | *n* (%) | *n* (%) | *n* (%) |
| None | 1 (25.0) | 1 (25.0) | 2 (66.7) | 2 (66.7) |
| Protein shakes/ bars/drinks/powders | 3 (75.0) | 3 (75.0) | 0 (0) | 1 (33.3) |
| Amino acids | 1 (25.0) | 1 (25.0) | 0 (0) | 0 (0) |
| Vitamins | 2 (50.0) | 2 (50.0) | 1 (33.3) | 0 (0) |
| Minerals | 1 (25.0) | 1 (25.0) | 1 (33.3) | 0 (0) |
| Omega-3 fish oils | 0 (0) | 0 (0) | 1 (33.3) | 0 (0) |

*Note.* Participants could select more than one supplement from a list of 13 options.

Skipping Meals

A frequency table was constructed to descriptively analyze reasons why participants may skip meals between groups and at different time points (Table 7). These reasons differed between groups throughout the investigation. With regard to how the frequency of certain reasons changed from baseline to the end of the control period, changes were minimal. The intervention and control groups experienced one frequency change each: “to manage my weight” and “food not available”, respectively.

Table 7

*Reasons for Skipping Meals for Intervention and Control Groups*

| | Intervention (*n* = 4) | | Control (*n* = 3) | |
|---|---|---|---|---|
| | Baseline | End of Control | Baseline | End of Control |
| Reason | *n* (%) | *n* (%) | *n* (%) | *n* (%) |
| Lack of time | 2 (50.0) | 2 (50.0) | 2 (66.7) | 2 (66.7) |
| Food not available | 1 (25.0) | 1 (25.0) | 1 (33.3) | 0 (0) |
| Training conflicts with meal times | 1 (25.0) | 1 (25.0) | 1 (33.3) | 1 (33.3) |
| Not hungry | 1 (25.0) | 1 (25.0) | 2 (66.7) | 2 (66.7) |
| To manage my weight | 1 (25.0) | 0 (0) | 0 (0) | 0 (0) |
| I do not skip meals | 1 (25.0) | 1 (25.0) | 0 (0) | 0 (0) |

*Note.* Participants could check more than one reason for skipping a meal from a list of seven options.

Desired Body Composition Changes

Desired body composition changes were descriptively analyzed between groups and at different time points. Both groups indicated minimal changes in frequencies over time. The frequencies are reflected in Table 8.

Table 8

*Desired Body Composition Changes for Intervention and Control Groups*

| Desired Change | Intervention (*n* = 4) | | Control (*n* = 3) | |
|---|---|---|---|---|
| | Baseline | End of Control | Baseline | End of Control |
| | *n* (%) | *n* (%) | *n* (%) | *n* (%) |
| I would like to weigh less | 1 (25.0) | 1 (25.0) | 3 (100) | 2 (66.7) |
| I would like to have less body fat | 3 (75.0) | 3 (75.0) | 3 (100) | 3 (100) |
| I would like to have more muscle | 4 (100) | 4 (100) | 2 (66.7) | 2 (66.7) |
| I am at a good body weight | 1 (25.0) | 2 (50.0) | 0 (0) | 0 (0) |
| My body composition is adequate | 0 (0) | 1 (25.0) | 0 (0) | 0 (0) |

*Note*. Participants could check more than one desired body composition change from a list of seven options.

Desired Nutritional Changes

Desired nutritional changes were also descriptively analyzed for each group over time. The intervention group indicated 13 total changes in frequency while the control group indicated eight changes. These frequencies are shown in Table 9.

Table 9

*Desired Nutritional Changes for Intervention and Control Groups*

| Reason | Intervention (*n* = 4) | | Control (*n* = 3) | |
|---|---|---|---|---|
| | Baseline | End of Control | Baseline | End of Control |
| | *n* (%) | *n* (%) | *n* (%) | *n* (%) |
| Eat more often | 1 (25.0) | 2 (50.0) | 0 (0) | 1 (33.3) |
| Eat more calories | 1 (25.0) | 3 (75.0) | 0 (0) | 0 (0) |
| Eat less often | 0 (0) | 0 (0) | 1 (33.3) | 2 (66.7) |
| Eat fewer calories | 1 (25.0) | 0 (0) | 2 (66.7) | 0 (0) |
| Eat a greater variety of foods | 2 (50.0) | 2 (50.0) | 0 (0) | 1 (33.3) |
| Eat healthier foods | 4 (100) | 3 (75.0) | 1 (33.3) | 1 (33.3) |
| Eat more fruits and vegetables | 0 (0) | 3 (75.0) | 1 (33.3) | 1 (33.3) |
| Learn more about good nutrition | 3 (75.0) | 0 (0) | 2 (66.7) | 1 (33.3) |
| Cook for myself | 1 (25.0) | 3 (75.0) | 1 (33.3) | 0 (0) |
| Get better access to healthy foods on campus | 1 (25.0) | 1 (25.0) | 0 (0) | 1 (33.3) |
| Get better access to healthy foods while traveling for competitions | 3 (75.0) | 3 (75.0) | 2 (66.7) | 2 (66.7) |

*Note.* Participants could check more than one desired nutritional change from a list of 13 options.

## Pretest, Posttest, Retention Changes

### Overall Measures

The overall results from the intervention from pretest to posttest to retention are displayed in Table 10. One-way repeated measures ANOVAs were used to determine if nutritional knowledge, self-efficacy, dietary behaviors, body composition, and exit velocity differed over time. Mauchly's Tests of Sphericity indicated that the assumptions of sphericity were met for each measure.

A significant effect of time on nutritional knowledge scores existed, $F(2, 12) = 31.453$, $p = .000$. Post hoc tests using Bonferonni corrections revealed a significant increase in mean total nutritional knowledge scores from pretest to posttest, $p = .004$. Participants scored higher on the nutritional knowledge posttest as compared to the pretest. No significance occurred in mean total nutritional knowledge scores from posttest to retention test, $p > .05$. The participants did not score higher on the retention test as compared to the posttest. Lastly, the overall increase in nutritional knowledge from pretest to retention was significant, $p = .003$). The participants scored higher on the retention test as compared to the pretest.

For self-efficacy scores, there was a significant effect of time, $F(2, 12) = 17.244$, $p = .000$. Post hoc tests using Bonferonni corrections revealed that the SNEI elicited a significant increase in total self-efficacy scores from pretest to posttest, $p = .037$. Participants scored higher in self-efficacy at posttest as compared to pretest. No changes occurred from posttest to retention test. Participants did not score differently in self-efficacy at retention as compared to posttest. However, the overall increase in self-efficacy scores from pretest to retention was significant, $p = .008$. Participants scored higher at retention as compared to pretest in self-efficacy.

No significant effects existed for time on total dietary behaviors scores, $F(2, 10) = 1.128$, $p = .362$, body fat percentages, $F(2, 12) = 1.211$, $p = .332$, fat free mass, $F(2, 12) = 1.278$, $p = .314$, or exit velocity, $F(2, 10) = 1.880$, $p = .203$. Participants did not attain differences in these measures at posttest or retention as compared to pretest. There were also no differences in participant measurements from posttest to retention.

Table 10

*Pretest, Posttest, and Retention Scores (n=7)*

| | Pretest | Posttest | Retention |
|---|---|---|---|
| Score | $M \pm SD$ | $M \pm SD$ | $M \pm SD$ |
| Total Nutritional Knowledge Score[a] | 26.71 ± 5.31 | 35.71 ± 5.15* | 36.43 ± 5.53* |
| Total Self-Efficacy Score[b] | 27.43 ± 3.51 | 34.57 ± 6.16* | 37.43 ± 6.21* |
| Total Dietary Behaviors Score[c] | 9.00 ± 1.41 | 9.86 ± 0.69 | 9.71 ± 1.38 |
| Body Composition (% Fat) | 23.50 ± 4.92 | 22.99 ± 5.20 | 24.73 ± 4.24 |
| Body Composition – Fat free mass (kg) | 54.60 ±3.17 | 55.26 ± 4.32 | 54.00 ± 3.80 |
| Exit Velocity (mph) (*n*=6) | 70.93 ±5.13 | 71.27 ± 6.75 | 73.88 ± 4.33 |

*Note*. *M* = Mean. *SD* = Standard Deviation. [a] = Out of a possible 49 points. [b] = Out of a possible 50 points. [c] = Out of a possible 15 points. *Significant from pretest. Significant at the $p < .05$ level.

Nutrition Subsections

One-way repeated measures ANOVAs were conducted for the seven subsections of the nutritional knowledge questionnaire to determine significant differences between time points. Mauchly's Tests of Sphericity indicated that the assumption of sphericity was met for all subsections. These results are reflected in Table 11.

No significant effects of time occurred for hydration, $F(2, 12) = 1.897$, $p = .192$, or weight control, $F(2, 12) = .644$, $p = .542$. Participants did not score differently in these subsections at posttest or retention as compared to pretest. There were also no differences in participant scores from posttest to retention for hydration and weight control knowledge.

The other five subsections showed significant differences over time. Significant effects of time existed for dietary supplement knowledge, $F(2, 12) = 18.839$, $p = .000$, general nutrition knowledge, $F(2, 12) = 7.125$, $p = .009$, protein knowledge, $F(2, 12) = 7.440$, $p = .008$, strategies knowledge, $F(2, 12) = 15.955$, $p = .000$. Post hoc tests using Bonferonni corrections revealed significant increases in supplement knowledge, $p = .005$, and strategies knowledge, $p = .012$, from pretest to posttest. Participants scored higher in supplement and strategies knowledge at posttest as compared to pretest. No changes occurred between posttest and retention for supplements, general nutrition, protein, or strategies knowledge. However, significance existed from pretest to retention in supplement, $p = .020$, general nutrition, $p = .033$, protein, $p = .050$, and strategies knowledge, $p = .003$. Participants scored higher in supplement, general nutrition, protein, and strategies knowledge at retention as compared to pretest. There was also significant effect of time on sport nutrition knowledge, $F(2, 12) = 5.919$, $p = .016$. However, due to lack of statistical power, post hoc analyses were unable to ascertain the significance between time points.

Table 11

*Pretest, Posttest, and Retention Nutrition Knowledge Scores by Subsection*

| | Pretest | Posttest | Retention |
|---|---|---|---|
| Score | *M* ± *SD* | *M* ± *SD* | *M* ± *SD* |
| Hydration[a] | 4.29 ± 1.11 | 5.29 ± 0.76 | 4.86 ± 0.90 |
| Weight Control[a] | 5.0 ± 1.41 | 5.43 ± 1.23 | 5.71 ± 1.38 |
| Dietary Supplements[b] | 2.57 ± 0.53 | 5.14 ± 1.35* | 4.86 ± 1.77* |
| General Nutrition[b] | 3.86 ± 1.68 | 5.43 ± 0.79 | 5.57 ± 1.27* |
| Sport Nutrition[a] | 4.86 ± 1.57 | 6.14 ± 0.69 | 6.00 ± 0.58 |
| Protein[a] | 5.29 ± 1.11 | 5.43 ± 1.27 | 6.14 ± 1.07* |
| Strategies[c] | 1.57 ± 0.79 | 2.86 ± 0.90* | 3.29 ± 1.38* |

*Note*. *M* = Mean. *SD* = Standard Deviation. [a]Subsection consisted of 7 possible points. [b]Subsection consisted of 8 possible points. [c]Subsection consisted of 5 possible points. *Significant from pretest. Significant at the $p < .05$ level.

Supplement Use

Dietary behavior changes regarding supplement use were minimal, as shown in Table 12. Four supplements were marked as being used at pretest: Protein shakes/bars/drinks/powders, amino acids, vitamins, and minerals. Three participants indicated no dietary supplement use. The only change in frequency was observed in amino acids. The frequency of use declined from one participant to none at both posttest and retention.

Table 12

*Pretest, Posttest, and Retention Supplement Use (n* = 7)

| | Pretest | Posttest | Retention |
|---|---|---|---|
| Supplement | *n* (%) | *n* (%) | *n* (%) |
| None | 3 (42.9) | 3 (42.9) | 3 (42.9) |
| Protein shakes/ bars/drinks/powders | 4 (57.1) | 4 (57.1) | 4 (57.1) |
| Amino acids | 1 (14.3) | 1 (14.3) | 0 (0) |
| Vitamins | 2 (28.6) | 2 (28.6) | 2 (28.6) |
| Minerals | 1 (14.3) | 1 (14.3) | 1 (14.3) |

*Note.* Participants could check more than one supplement from a list of 13 options.

<u>Skipping Meals</u>

Changes in frequency for reasons for skipping meals were also minimal over time. There was a single increase in the reason “food not available” from pretest to posttest. “To manage my weight” and “not hungry” experienced a single decrease in frequency over time. The frequencies are shown in Table 13.

Table 13

*Pretest, Posttest, and Retention Reasons for Skipping Meals* (*n* = 7)

| Reason | Pretest *n* (%) | Posttest *n* (%) | Retention *n* (%) |
|---|---|---|---|
| Lack of time | 4 (57.1) | 4 (57.1) | 4 (57.1) |
| Food not available | 1 (14.3) | 2 (28.6) | 2 (28.6) |
| Training conflicts with meal times | 2 (28.6) | 2 (28.6) | 2 (28.6) |
| Not hungry | 3 (42.9) | 3 (42.9) | 2 (28.6) |
| To manage my weight | 1 (14.3) | 0 (0) | 0 (0) |
| I do not skip meals | 1 (14.3) | 1 (14.3) | 1 (14.3) |

*Note.* Participants could check more than one reason for skipping a meal from a list of seven options.

Desired Body Composition Changes

Desired body composition changes were descriptively analyzed at different time points (Table 14). Changes were minimal over time. At posttest, there was a single increase in three desires: “I would like to have more muscle”, “I am at a good body weight”, and “my body composition is adequate”.  From posttest to retention, there were decreases in the desires “I would like to have less body fat” and “I am at a good body weight”.

Table 14

*Pretest, Posttest, and Retention Desired Body Composition Changes* (*n* = 7)

| | Pretest | Posttest | Retention |
|---|---|---|---|
| Desired Change | *n* (%) | *n* (%) | *n* (%) |
| I would like to weigh less | 3 (42.9) | 3 (42.9) | 3 (42.9) |
| I would like to have less body fat | 6 (85.7) | 6 (85.7) | 5 (28.6) |
| I would like to have more muscle | 6 (85.7) | 7 (100) | 7 (100) |
| I am at a good body weight | 1 (14.3) | 2 (28.6) | 1 (14.3) |
| My body composition is adequate | 0 (0) | 1 (14.3) | 1 (14.3) |

*Note.* Participants could check more than one desired body composition change from a list of seven options.

Desired Nutrition Changes

The most changes in frequencies occurred in desired nutrition changes. At posttest, participants indicated more frequent desires to eat more often, eat more calories, eat more fruits and vegetables, cook for themselves, and get better access to healthy foods on campus. Participant frequencies were decreased in desires to eat less often, eat healthier foods, and learn more about good nutrition. Additional changes were indicated at retention. Participants specified eight additional changes in frequencies of desired nutritional changes at retention as compared to posttest. These changes are shown in Table 15.

Table 15

*Pretest, Posttest, and Retention Desired Nutrition Changes* (*n* = 7)

| Desired Change | Pretest<br>*n* (%) | Posttest<br>*n* (%) | Retention<br>*n* (%) |
|---|---|---|---|
| Eat more often | 2 (28.6) | 3 (42.9) | 5 (71.4) |
| Eat more calories | 1 (14.3) | 4 (57.1) | 4 (57.1) |
| Eat less often | 2 (28.6) | 0 (0) | 1 (14.3) |
| Eat fewer calories | 1 (14.3) | 1 (14.3) | 0 (0) |
| Eat a greater variety of foods | 3 (42.9) | 3 (42.9) | 3 (42.9) |
| Eat healthier foods | 5 (71.4) | 4 (57.1) | 4 (57.1) |
| Eat more fruits and vegetables | 1 (14.3) | 5 (71.4) | 5 (71.4) |
| Learn more about good nutrition | 4 (57.1) | 1 (14.3) | 1 (14.3) |
| Cook for myself | 1 (14.3) | 4 (57.1) | 2 (28.6) |
| Get better access to healthy foods on campus | 2 (28.6) | 3 (42.9) | 1 (14.3) |
| Get better access to healthy foods while traveling for competitions | 5 (71.4) | 5 (71.4) | 2 (28.6) |

*Note.* Participants could check more than one desired nutrition change from a list of 13 options.

## Intentions

The results from the reflective and future intentions surveys are shown in Table 16 and Table 17, respectively. Two way mixed ANOVAs were used to analyze the interaction between groups and time for future and reflective intentions. There were no significant differences in overall mean scores for both groups from week to week for future intentions, $F(1, 4) = .055$, $p = .994$), or reflective intentions, $F(1, 5) = .265$, $p = .928$. Participants in either group did not score differently on future or reflective intentions to eat a healthy diet over time.

However, significant differences between groups occurred in week 1, $p = .018$, week 2, $p = .025$, week 4, $p = .018$, and week 5, $p = .044$. Participants in the control group score higher on future intentions four out of five weeks of intervention. There was no significant difference between future intention scores for the intervention and control group in week 3. Further, no significant differences existed in reflective intentions between groups at any time point.

Table 16

*Future Intentions*

| | Control ($n = 3$) | Intervention ($n = 4$) | Total ($n = 7$) |
|---|---|---|---|
| Time | $M \pm SD$ | $M \pm SD$ | $M \pm SD$ |
| Week 1 | $7.0 \pm 0^{*}$ | $5.63 \pm 0.32$ | $6.21 \pm 0.77$ |
| Week 2 | $6.92 \pm 0.14^{*}$ | $5.63 \pm 0.97$ | $6.18 \pm 0.98$ |
| Week 3 | $6.92 \pm 0.14$ | $5.81 \pm 0.90$ | $6.29 \pm 0.87$ |
| Week 4 | $7.0 \pm 0^{*}$ | $5.63 \pm 1.01$ | $6.21 \pm 1.02$ |
| Week 5 | $6.83 \pm 0.29^{*}$ | $5.69 \pm 1.11$ | $6.18 \pm 1.01$ |

*Note*. *M* = Mean. *SD* = Standard Deviation. $^{*}$Significant between groups. $^{**}$Significant between time periods. Significant at the $p < .05$ level.

Table 17

*Reflective Intentions*

| Time | Control ($n$ = 3) | Intervention ($n$ = 4) | Total ($n$ = 7) |
|---|---|---|---|
| | $M \pm SD$ | $M \pm SD$ | $M \pm SD$ |
| Week 2 | 6.34 ± 0.58 | 4.84 ± 0.69 | 5.48 ± 1.00 |
| Week 3 | 6.0 ± 0.88 | 5.58 ± 1.17 | 5.76 ± 1.00 |
| Week 4 | 6.11 ± 0.19 | 5.58 ± 1.26 | 5.81 ± 0.94 |
| Week 5 | 6.11 ± 0.77 | 5.09 ± 1.55 | 5.53 ± 1.30 |
| Posttest | 6.11 ± 0.51 | 5.17 ± 1.26 | 5.57 ± 1.07 |
| Retention | 6.33 ± 0.58 | 5.17 ± 1.26 | 5.67 ± 1.14 |

*Note.* $M$ = Mean. $SD$ = Standard Deviation. *Significant between groups. **Significant between time periods. Significant at the $p < .05$ level.

## Summary of Findings

In summary, there were no significant differences between baseline and end of the control period scores for the intervention or control group in nutritional knowledge, self-efficacy, dietary behaviors, body composition, or exit velocity. A significant difference existed between the intervention and control group in self-efficacy at baseline, but no other differences between the intervention and control group existed at either time point in nutritional knowledge, self-efficacy, dietary behaviors, body composition, or exit velocity. For nutritional knowledge subsections, the intervention group had significantly higher scores in dietary supplement knowledge at the end of the control period as compared to baseline. Dietary supplement and strategies knowledge was significantly higher in the intervention group at the end of the control period as compared to the control group. No other differences between groups and over time were found. The SNEI did not elicit a notable difference between the intervention and control groups in frequency changes for supplement use, reasons for skipping meals, desired body composition changes, or desired nutritional changes over time.

When comparing the behavior of all participants, nutritional knowledge and self-efficacy were significantly increased at posttest and retention as compared to pretest scores. No other significant changes were found for nutritional knowledge, self-efficacy, dietary behaviors, body composition, or exit velocity. Dietary supplement and strategies knowledge subsections were significantly increased at posttest as compared to pretest. Dietary supplement, general nutrition, protein, and strategies knowledge were significantly increased at retention as compared to pretest. No other significant changes were found for nutritional knowledge subsections over time. The SNEI did not elicit a prominent difference over time in frequency changes for supplement use, reasons for skipping meals, desired body composition changes, or desired nutritional changes. Lastly, while the control group showed significantly higher future intentions to eat a healthy diet in four out of the five weeks during intervention, no other significant differences existed between groups or over time for future or reflective intentions.

# CHAPTER V

# DISCUSSION

The purpose of this study was to investigate the effects of an SNEI on nutritional knowledge, perceived nutritional self-efficacy, dietary habits, body composition, and performance in NCAA Division I female softball players, and to measure retention and effects of this knowledge after the SNEI period. Questionnaires assessing nutritional knowledge, self-efficacy, dietary habits, and intentions to eat a healthy diet were utilized, in addition to body composition measurements and exit velocities. Results were compared for an intervention and control group, as well as the combined group of participants over time.

## Nutritional Knowledge

The research question regarding nutritional knowledge was if an SNEI improves nutritional knowledge over time. Participants were expected to score higher on the posttest than the pretest, and not score differently on the retention test than the posttest, but still higher than the pretest on nutritional knowledge. When considering the entire sample from pretest to posttest to retention, total nutritional knowledge scores increased from pretest to posttest, and were retained from posttest to retention. Participants' nutritional knowledge scores as percentages changed from 54.51% to 72.89% to 74.34%. These scores are reflective of other studies that report nutritional knowledge scores for collegiate athletes prior to intervention at approximately 50% (Abood et al., 2004; Cholewa et al., 2015; Dunn et al., 2007; Hornstrom et al., 2011; Rossi et al., 2017), and increase to around 70% following intervention (Abood et al., 2004; Cholewa et al., 2015; Rossi et al., 2017).

Interestingly, only the nutrition subsection scores of dietary supplements and strategies were significantly improved at posttest. The dietary supplements and strategies also had the lowest scores at pretest (32% and 31%, respectively) and thus had the most opportunity for improvement. Specifically, the scores for dietary supplement knowledge reflect previous literature wherein athletes' initial knowledge of dietary supplements has been reported as low (Karpinski, 2011), perhaps due to the large amount of available dietary supplements to choose from for different health and performance effects (Maughan et al., 2018). It should also be noted that athletes in prior research tend to report a high prevalence for dietary supplement use (Maughan, Depiesse, & Geyer, 2007), which is in contrast to the current study's usage of only vitamins, minerals, protein, and amino acids at pretest. The lack of usage is not necessarily related to low knowledge of supplements; rather, only one participant at pretest (14.3%) and two participants at retention (28.6%) indicated they felt that taking dietary supplements gave them a competitive edge. The participants in this study may not have had interest in taking nutrition supplements, potentially from a lack of knowledge or desire. Additionally, none of the participants reported their trainer to be a top source of nutrition information, although SCSs and ATs have been reported to score the highest on dietary supplement knowledge in relation to other measures (Torres-McGehee et al., 2012). To improve the status of dietary supplement knowledge among athletes, programs should encourage relationships between athletes and athletic trainers.

Additionally, participants who completed an SNEI were expected to score higher in nutritional knowledge as compared to a control. This hypothesis was not supported by the current study's results, wherein no significant differences existed between groups or over time for total nutritional knowledge scores. However, the nutritional knowledge subsections of dietary supplements and strategies were significantly increased as compared to control group at the end of the control period. Supplements scores were also increased for the intervention group following intervention for possible reasons as mentioned above.

The lack of differences between the control and intervention group is unexpected. It is possible the control group may have acquired knowledge outside of the education sessions, allowing them to score higher on the retest at the end of the control period, and thus not significantly different than the intervention groups. Additionally, retesting effects may have exerted influence on the control group, leading them to score higher on nutritional knowledge after the control period despite not attending education sessions (Hausknecht, Halpert, Di Paolo, & Moriarty Gerrard, 2007). The improvement in score for the control may be attributed to reduced anxiety or memory of previous answers allowing for higher retest scores.

The overall results for nutritional knowledge suggest that the SNEI contributed to the improvement in nutritional knowledge, but outside factors may have also contributed to increases in nutritional knowledge. The SNEI was most successful in improving scores for the knowledge of dietary supplements. Perhaps most importantly, improvement in overall nutritional knowledge was retained at three weeks post intervention. This may suggest that participants who receive an SNEI may continue to seek and acquire nutritional knowledge after the intervention, as noted in other populations (Brink & Sobal, 1994).

## Self-Efficacy

Based on previous literature, it was expected that participant self-efficacy in nutrition would increase throughout the investigation. When considering all participants, self-efficacy scores increased from pretest to posttest and retention (Abood et al., 2004; Bolles, 2008; Karpinski, 2011), but not from posttest to retention. Percentages for self-efficacy scores changed from 55% to 69% to 75%. Pretest scores were lower than those reported by others (e.g., 65% to 70%) in athletes prior to intervention (Abood et al., 2004; Bolles, 2008; Karpinski, 2011), while the posttest scores were more reflective of the average pre-intervention self-efficacy scores in prior research. These results indicate that nutritional self-efficacy is increased following an SNEI and retained at three weeks post intervention, which is in contrast to previous literature suggesting decreases in self-efficacy after interventions with athletes (Doyle-Lucas & Davy, 2011).

Counter to the hypothesis, the self-efficacy of the intervention and control groups did not change from baseline to the end of the control period. These scores contrast those of the entire group of participants throughout the study, who experienced a significant increase following the intervention; as well previous literature suggesting that exposure to nutritional knowledge increases nutritional self-efficacy (Karpinski, 2011). The discrepancies highlight the need for additional randomized-controlled trials on self-efficacy in athletes in relation to SNEIs. The understanding of why this increase occurs, specifically in athletic populations, is necessary to best structure interventions aiming to improve nutritional self-efficacy with hopes to incur behavioral change (Abood et al., 2004).

## Dietary Behaviors

Dietary behaviors scores were expected to increase from pretest to posttest to retention in tangency with the expectation that self-efficacy scores would also increase. This was unsupported by the results, as no significant changes existed in dietary behaviors over time. Additionally, participants in the intervention group were also expected to score higher in favorable dietary behaviors as compared to a control at the end of the control period. However, no significant differences were found between groups over time. Dietary behaviors scores remained at approximately 60% to 65% throughout the study, supporting previous literature indicating less than ideal fueling habits in female athletes (Hinton et al., 2004; Nepocatych et al., 2017; Shriver et al., 2013). These results align with previous research suggesting a lack of translation of nutritional knowledge into practice (Alaunyte et al., 2015; Collison et al., 1996; Martinelli, 2013; Rossi et al., 2015); although others contest that nutritional knowledge does lead to change in dietary habits (Abood et al., 2004; Garthe, Raastad, & Sundgot-Borgen, 2011; Hornstrom et al., 2011; Nichols et al., 2005; Valliant et al., 2012).

Furthermore, the intervention appeared to have a minimal effect on changing frequencies of supplement use, reasons for skipping meals, and desired body composition changes between the intervention and control groups, and for all participants from pretest to posttest to retention. The most changes in frequencies throughout the investigation were in desired nutritional changes, such as increases in the desire to eat more often, eat more calories, and eat more fruits and vegetables. These changes are notable considering previous research indicates female athletes tend to have low EIs (Hinton et al., 2004; Nepocatych et al., 2017). However, the overall changes in frequencies were still relatively minimal, further indicating a lack of behavioral change following the SNEI.

In this investigation, the lack of increase in favorable dietary behaviors is contrasted with overall increases in nutritional knowledge and self-efficacy. Few other studies have noted changes in dietary habits after the intervention period in athletes (Doyle-Lucas & Davy, 2011; Yannakoulia et al., 2002), with dietary habits declining or remaining unchanged from the posttest. However, dietary behaviors should be examined at later time points following an SNEI to determine if favorable dietary behaviors would increase, decrease, or remain constant.

## Body Composition and Exit Velocity

Intervention group participants were expected to move towards more favorable body compositions (i.e., less body fat, more lean mass) when compared to the control group. However, no differences between groups or over time were found. When comparing pretest, posttest, and retention results, body fat percentage and fat free mass did not change. While other studies have shown favorable changes in body composition following nutrition education (Buffington et al., 2016; Garthe, Raastad, & Sundgot-Borgen, 2011; Nascimento et al., 2016; Rossi et al., 2017), the lack of significant changes in this study is not surprising as there were no significant changes in dietary behaviors scores in either the comparison between the intervention and control groups, nor for all participants over time.

The measure of performance for the investigation was exit velocity. It was expected that exit velocity would increase as body compositions became more favorable for sport (Lowe et al., 2010). There were no significant differences throughout the investigation, both when comparing the intervention and control groups, and all participants over time. However, since there was no significant change in lean mass in either group, or differences between groups at either point, it is reasonable that no significant differences in exit velocity were present either.

Previous studies have reported changes in performance following nutritional counseling (Garthe, Raastad, and Sundgot-Borgen, 2011; Rossi et al., 2017). Specifically, Rossi and colleagues (2017) reported increases in some performance measurements in collegiate baseball players who completed an SNEI. However, Rossi and colleagues also reported changes in dietary behaviors and body fat mass in their intervention group. Additionally, the control group in their study also experienced increases in lean mass and other performance measures with no differences from the intervention group. Thus, since some measurements were increased in both their intervention and control groups while others were not, further research is needed to understand if the improvements are a result of body composition changes from nutritional education or from other variables. These understandings could help explain why there were no differences in body composition or performance in the current investigation, wherein the intervention group experienced no significant changes in relation to the control.

Additionally, body composition and performance changes in response to nutritional counseling or education have been noted in studies lasting 12 weeks (Garthe, Raastad, & Sundgot-Borgen, 2011; Rossi et al., 2017), whereas the current study’s SNEI period spanned nine weeks. These are both notably different lengths compared to the recommended best practice of five months for successful nutrition interventions (Murimi et al., 2017). Additional research in SNEI length with regard to body composition and performance changes may reveal if more time is necessary to elicit full theoretical effects of SNEIs.

Lastly, athletes are typically engaged in physical training throughout the academic year. Therefore, it is possible that some noted improvements in performance in other studies might be from physical training and not exclusively from improvements in nutritional knowledge (Rossi et al., 2017). Additionally, the participants in this study are high-level athletes and may already be near the peak of their performance in terms of highest exit velocity, perhaps leading to the lack of significant change in performance. Future studies should incorporate structured randomized controlled trials over longer periods of time (e.g., multiple athletic seasons) to understand how nutritional knowledge changes impact body composition and performance in addition to a physical training component.

## Intentions to Change

Participants demonstrated an overall high level of intent to eat a healthy diet from week to week. Future intentions’ mean scores were consistently higher than reflective intentions’ mean scores. This can likely be attributed to athletes’ general positive attitudes about eating healthy for sport (Dunn et al., 2007), which correspond with the majority of participants' indicating desires to change both their nutrition habits and body compositions. However, the reflective intentions show that athletes may have struggled to actually implement new changes, which is further reflected in their unchanged dietary habits. The discrepancy between intentions to eat a healthy diet based on the intervention and changes to favorable dietary behaviors suggests that other variables may be involved, such as external barriers preventing the ability to execute desired changes. Collegiate student athletes have unique schedules and access to food. They may be limited in time and money they can use for food preparation and eating, and their dietary choices may be limited by dining hall offerings or access to grocery stores (Hornstrom et al., 2011; Zawila et al., 2003). These barriers could prevent the translation of nutritional knowledge and increased self-efficacy into increased favorable dietary behaviors. Further research should examine these barriers to understand why collegiate athletes often do not adopt favorable dietary habits after increasing their nutritional knowledge.

## Practical Implications

Several practical implications can be offered from the results of the current study. First, a five-week SNEI with components of SCT was sufficient to significantly increase nutritional knowledge and self-efficacy in this sample. Coaches seeking to enhance and sustain a similar sample's nutritional knowledge and self-efficacy for at least three weeks following intervention may be able to do so with approximately five hours of education. Second, a five-week SNEI was not sufficient to incur dietary behavior, body composition, or performance changes in this sample. Incorporating an SNEI with the goal to increase these measures in a similar sample may not be successful. Third, coaches should highlight the availability of a team AT. None of the participants in this sample indicated their AT to be a top source of nutritional information. However, ATs have been reported to score the highest in adequate nutritional knowledge in relation to coaches or teammates, and especially knowledgeable on dietary supplements (Torres-McGehee et al., 2012). Lastly, coaches should work on emphasizing positivity around body composition for sport. Only one participant in this sample indicated they felt their body composition was adequate despite an overall mean of approximately 25% body fat. This is less than other elite softball programs reporting approximately 33% (Nepocatych et al., 2017).

## Future Directions

Future investigations should examine the effects of an SNEI on larger samples; specifically, the relationship between self-efficacy and dietary behaviors should be explored. Additionally, it is important to ascertain any changes in nutritional knowledge at various lengths after the intervention period, as well as changes in dietary behaviors and nutritional self-efficacy. Some research on nutrition education interventions suggests that the length of the intervention should be longer than five months (Murimi et al., 2017), but more research is needed to determine if this is best practice for athletic populations as well. This information could help inform future efforts to educate athletes, including if and when refresher courses are necessary to see optimal retention and behavior changes.

Additionally, the goals of future interventions should be considered. Although intentions are related to behavioral change, there does appear to be a gap that exists between intention and behavior. One variable that has been suggested in addition to self-efficacy is perceived behavioral control, or the perception of ease in adopting a behavior (Amireault, Godin, Vohl, & Perusse, 2008). Assessing and working on improving perceived behavioral control in regard to nutrition may lead to improved dietary habits, as perceived behavioral control reveals the extent to which the participants feel the behavior is under their control and not outside control. This may be especially insightful considering the constraints placed on collegiate athletes specifically (Hinton et al., 2004). Other variables to consider may be past behaviors (Amireault et al., 2008), and readiness to change.

Additionally, the transtheoretical model of behavior change (TTM) has been proposed as an effective way to incur behavior changes towards optimal health (Prochaska, Johnson, & Lee, 1998). Within this model, several stages of behavioral change are described, including precontemplation, contemplation, preparation, action, and maintenance. The model suggests that the readiness to change a behavior must first be ascertained to then successfully modify the behavior through different intervention tactics, and has shown some success with female athletes and sport-related behaviors (Aizawa et al., 2019). Additionally, barriers to dietary behavior change should be investigated, specifically in female collegiate athletes. Identification of these barriers can help elucidate solutions for helping athletes achieve desired nutritional and body composition changes relevant to sport performance. Largely, future studies should seek to identify the most effective underlying frameworks for nutrition interventions that result in successful and enduring behavioral change in athletes.

## Conclusions

In conclusion, the results from this investigation support existing literature that collegiate athletes score relatively low on nutritional knowledge assessments and that nutrition education can increase nutritional knowledge and self-efficacy scores. However, increases in nutritional knowledge and self-efficacy, in combination with high intentions to eat proper diets for sport performance, are not sufficient to see significant changes in dietary behaviors over a nine-week period. Consequently, body composition and performance measures also remained unchanged. Notably, it appears that nutritional knowledge and self-efficacy were retained at three weeks post intervention, suggesting that a short-term SNEI may be sufficient to see prolonged improvement in these measures. Further research is needed to understand best practices in SNEI structure that will successfully improve favorable dietary behaviors in athletes, leading to improved body composition and performance in sport.

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# APPENDIX A

# DIETARY BEHAVIORS AND NUTRITION KNOWLEDGE QUESTIONNAIRE

**DIETARY BEHAVIORS AND NUTRITION KNOWLEDGE QUESTIONNAIRE** Date:
ID#:

*Please* ***do not*** *write your name on this questionnaire*.

## SECTION A. - DEMOGRAPHIC INFORMATION

1. What age were you on your last birthday (*in years*)? __________

2. What is your ethnic origin?
   - O White
   - O Black
   - O Asian
   - O Hispanic
   - O Other: ________________

3. What year are you in at school?
   - O Freshman
   - O Sophomore
   - O Junior
   - O Senior
   - O Graduate

4. What year of athletic eligibility are you? (select all that apply)
   - O Freshman
   - O Sophomore
   - O Junior
   - O Senior
   - O Redshirt

5. Do you currently have any practice / playing restrictions (e.g., from injury)
   - O Yes – no participation
   - O Yes – limited participation
   - O No – full participation

6. During the school year, where do you live?
   - O On-campus
   - O Off-campus

7. Do you have a meal-plan through the university?
   - O Yes – Full
   - O Yes – Partial
   - O No

8. Have you attended a sports nutrition course/talk in the last 12 months?
   - O Yes
   - O No

9. Do you have access to a sports nutritionist / dietitian?
   - O Yes
   - O No

10. Please rate your top 5 sources of nutrition information (with 1 being your main source)
    - ____ Magazines / Popular nutrition books
    - ____ Health food stores / shops
    - ____ Friends/ Teammates
    - ____ Academic journals / Nutrition textbooks
    - ____ Media / Internet
    - ____ Sports dietitian / Nutritionist
    - ____ Doctor / Nurse
    - ____ Parents / Family
    - ____ Sports workshops / courses
    - ____ Coach / trainer

11. How would you rate your current sports nutrition knowledge?
    - O Poor
    - O Fair
    - O Good
    - O Very good
    - O Excellent

12. How much attention do you currently give to your nutrition?
    - O None
    - O A little
    - O A fair amount
    - O A lot

13. In regard to your body composition, check all of the following statements that apply:

- _______ I would like to weigh less
- _______ I would like to have less body fat
- _______ I would like to weigh more
- _______ I would like to have more muscle
- _______ I am at a good body weight
- _______ My body composition is adequate
- _______ Other. Explain:

  ______________________________________________

SECTION B. PLEASE ANSWER THE FOLLOWING QUESTIONS BASED ON YOUR USUAL DIET PATTERN WHEN YOU ARE TRAINING AND COMPETING

1. Are you following any specific diet:
   O Not following any specific diet
   O Diabetic
   O Celiac
   O Vegetarian
   O Vegan
   O Trying to lose weight
   O Trying to gain weight
   O Lactose intolerant
   O Wheat intolerant
   O Other: _____________
   O Food Allergies: Yes / No
      - If yes, please specify:____________________

2. Please indicate which nutritional supplements you are currently taking (select all that apply)
    - O I am not taking any nutritional supplements
    - O Creatine
    - O Caffeine tablets/ supplements
    - O Protein shakes/ bars/ drinks/ powders
    - O Amino acids (e.g., leucine, arginine, alanine)
    - O Vitamins (e.g., multi or single, vitamin C or E)
    - O Minerals (e.g., iron, calcium, magnesium)
    - O Herbal supplements (e.g., Echinacea, Garlic, Ginseng)
    - O Glucosamine/ Chondroitin
    - O "Fat burners" (e.g., TrimSpa, Lipodrene, Ephedrine)
    - O Sodium Citrate/ Bicarbonate
    - O Omega 3 fish oils
    - O Other: ____________________________

3. I drink only when I am thirsty in training / competition
    - O Yes
    - O <u>No</u>

4. I eat after training only if I am hungry
    - O Yes
    - O <u>No</u>

5. Taking sports nutrition supplements gives me the competitive edge I need for competing
    - O Yes
    - O <u>No</u>

6. I pay attention to what I eat and eat a wide variety of foods
    - O <u>Yes</u>
    - O No

7. I eat a high protein diet (meat, poultry, fish, eggs, cheese) to build up my muscles and get stronger
    - O Yes
    - O <u>No</u>

8. I often drink alcohol after a training session
    - O Yes
    - O <u>No</u>

9. I generally eat:
   - O 1 to 2 meals per day
   - O 3 meals per day
   - O 4 to 5 meals per day
   - O More than 5 meals per day

10. If I skip meals I am more likely to miss:
   - O Breakfast
   - O Lunch
   - O Dinner
   - O I do not skip meals

11. My main reason for skipping meals is: (select all that apply)
   - O Lack of time
   - O Food not available
   - O Training conflicts with meal times
   - O Not hungry
   - O To manage my weight
   - O Not enough money
   - O I do not skip meals

12. My diet is based mainly on:
   - O High protein foods (meat, fish, eggs, cheese, poultry)
   - O High fat foods (sausages, chocolates, pies, cakes with butter and cream, full fat dairy)
   - O High carbohydrate foods (breads, pasta, rice, potatoes, cereals)
   - O A wide variety of different foods

13. I would describe my overall eating habits as:
   - O Poor
   - O Fair
   - O Good
   - O Very good
   - O Excellent

14. How important is good nutrition to sports performance?
   - O Very important
   - O Somewhat important
   - O Not important
   - O Unsure

15. If I could improve my nutrition, what changes would I make: (select all that apply)

O Eat more often

O Eat more calories

O Eat less often

O Eat fewer calories

O Eat a greater variety of foods

O Eat healthier foods

O Eat more fruits and vegetables

O Learn more about good nutrition

O Cook for myself

O Eat out less

O Get better access to healthy foods on campus

O Get better access to healthy foods while traveling for competitions

O I do not need to improve my nutrition

SECTION C. THIS SECTION WILL ASK YOU ABOUT HYDRATION DURING EXERCISE. PLEASE ANSWER ALL THE QUESTIONS AS BEST YOU CAN. EACH QUESTION/STATEMENT WILL HAVE ONE CORRECT ANSWER.

1. Athletes should drink fluid during exercise in order to:

O Balance nutrient and electrolyte levels

O Balance carbohydrate levels

O <u>Replace fluid lost from sweating</u>

O Help reduce the formation of free radicals in the muscles at work

2. When athletes are severely dehydrated (more than 4% of body mass lost)

O They can feel very tired after they exercise

O They can experience dizziness and headaches

O Their endurance during exercise may be diminished in a hot environment

O <u>All of the above</u>

3. If high sweat losses are anticipated during exercise, fluids should be taken beforehand

O <u>True</u>

O False

O Unsure

4. The ideal performance of carbohydrate in a commercially available isotonic sports drink for consumption **during** exercise is:
   - O <u>4-8%</u>
   - O 9-12%
   - O 13-17%
   - O 18-22%

5. Weighing individuals before and after training/competing is a good way of determining each individual's fluid requirements
   - O <u>True</u>
   - O False
   - O Unsure

6. A heavy intake of alcohol the day before training/competition can increase urine losses and lead to dehydration
   - O <u>True</u>
   - O False
   - O Unsure

7. If insufficient fluid is taken during exercise, which of the following changes poses the greatest risk to the athlete's health:
   - O <u>Increased core temperature</u>
   - O Loss of electrolytes in sweat
   - O Heat cramps
   - O Impaired muscle function

SECTION D. THIS SECTION WILL ASK YOU ABOUT ISSUES REGARDING WEIGHT CONTROL. PLEASE ANSWER ALL THE QUESTIONS AS BEST YOU CAN. EACH QUESTION/STATEMENT WILL HAVE ONE CORRECT ANSWER.

1. The **best way** for an athlete to gain lean body weight (muscle) is by:
   - O Consuming 'meal replacements' in addition to meals
   - O <u>There are no general principles, it is highly individualistic</u>
   - O Increasing foods high in fat in the diet
   - O Taking glutamine supplements

2. When long term weight loss is desired, athletes should:
   - O <u>Lose at most 1-2 lbs (0.5-1 kg) of body fat per week</u>
   - O Cut out fat in the diet
   - O Cut out sugar in the diet
   - O Aim for a weight loss of 5% of body weight per week

3. An athlete's nutritional needs depend mainly on their body mass, sport and training program
   - O <u>True</u>
   - O False
   - O Unsure

4. Athletes on severely restricted energy intakes could benefit from taking a low dose multivitamin/mineral supplement
   - O <u>True</u>
   - O False
   - O Unsure

5. Vitamin supplements aid weight gain in athletes
   - O True
   - O <u>False</u>
   - O Unsure

6. Specific foods (i.e., pineapples & grapefruit) have special value in weight loss diets as these foods can burn body fat
   - O True
   - O <u>False</u>
   - O Unsure

7. Reducing daily energy intake by 500 kcals can lead to a weekly loss of 0.5 kg (1lb) of body fat
   - O <u>True</u>
   - O False
   - O Unsure

SECTION E. THIS SECTION WILL ASK YOU ABOUT DIETARY SUPPLEMENTS. PLEASE ANSWER ALL THE QUESTIONS AS BEST YOU CAN. EACH QUESTION/STATEMENT WILL HAVE ONE CORRECT ANSWER.

1. What are the primary functions of vitamins and minerals?
   - O To increase muscular tissue
   - O To burn body fat
   - O <u>To catalyze biochemical reactions in the body</u>
   - O To provide energy

2. Creatine can be used in a resistance training program to increase lean body mass and strength
   - O <u>True</u>
   - O False
   - O Unsure

3. An iron supplement should be taken when an athlete feels constantly tired
   - O True
   - O <u>False</u>
   - O Unsure

4. Solid evidence has shown that Vitamin B complex supplements allow athletes to recover faster and perform better
   - O True
   - O <u>False</u>
   - O Unsure

5. Solid evidence has shown that ginseng improves exercise performance in athletes
   - O True
   - O <u>False</u>
   - O Unsure

6. The supplement hydroxymethylbutyrate (HMB) enhances energy production and reduces fatigue during exercise in athletes. This statement is:
   - O True
   - O <u>False</u>
   - O Unsure

7. Caffeine has been shown to improve endurance performance in athletes
   - O True
   - O False
   - O Unsure

8. All nutrition supplements commercially available on the market have been scientifically tested and are safe to use
   - O True
   - O False
   - O Unsure

SECTION F. THIS SECTION WILL ASK YOU ABOUT GENERAL NUTRITION INFORMATION. PLEASE ANSWER ALL THE QUESTIONS AS BEST YOU CAN. EACH QUESTION/STATEMENT WILL HAVE ONE CORRECT ANSWER.

1. The main ingredient is listed **last** on a food label
   - O True
   - O False
   - O Unsure

2. A lack of iron in the diet can lead to fatigue and illness
   - O True
   - O False
   - O Unsure

3. Which vitamin is **most likely** to be toxic if consumed in excess amounts for a long period of time?
   - O Vitamin C
   - O Vitamin A
   - O Vitamin B12
   - O Vitamin B1

4. Vitamin C aids the absorption of dietary iron in the body
   - O True
   - O False
   - O Unsure

5. A gram of fat has over twice as many calories as a gram of protein or carbohydrate
   - O <u>True</u>
   - O False
   - O Unsure

6. Which is the best source of dietary iron?
   - O <u>Liver</u>
   - O Spinach
   - O Oily fish
   - O Whole-grain bread

7. Brown sugar is a healthier alternative to white sugar
   - O True
   - O <u>False</u>
   - O Unsure

8. Prolonged calcium deficiency can lead to stress fractures and osteoporosis
   - O <u>True</u>
   - O False
   - O Unsure

SECTION G. THIS SECTION WILL ASK YOU ABOUT SPORTS NUTRITION. PLEASE ANSWER ALL THE QUESTIONS AS BEST YOU CAN. EACH QUESTION/STATEMENT WILL HAVE ONE CORRECT ANSWER.

1. Carbohydrate loading is crucial for an athlete competing in a sprint event
   - O True
   - O <u>False</u>
   - O Unsure

2. A diet with little or no fat is the best diet for an athlete
   - O True
   - O <u>False</u>
   - O Unsure

3. Most athletes should restrict high fat meals in the few hours before competing
   - O <u>True</u>
   - O False
   - O Unsure

4. Some athletes may require more sodium (salt) in their diet then less active people
   - O <u>True</u>
   - O False
   - O Unsure

5. Large amounts of alcohol after exercise can impair the refueling and recovery process
   - O <u>True</u>
   - O False
   - O Unsure

6. Nutrition is important only in the competition season for athletes
   - O True
   - O <u>False</u>
   - O Unsure

7. Carbohydrate is stored in the body as glycogen in the muscles and liver
   - O <u>True</u>
   - O False
   - O Unsure

SECTION H. THIS SECTION WILL ASK YOU ABOUT PROTEIN. PLEASE ANSWER ALL THE QUESTIONS AS BEST YOU CAN. EACH QUESTION/STATEMENT WILL HAVE ONE CORRECT ANSWER.

1. Taking protein and amino acid supplements can increase muscle mass without training
   - O True
   - O <u>False</u>
   - O Unsure

2. Including protein in the recovery foods after training/competing can help with muscle repair and rebuilding
   - O <u>True</u>
   - O False
   - O Unsure

3. Excess protein calories from the diet can be stored as fat
   - O <u>True</u>
   - O False
   - O Unsure

4. Protein is the **main** source of energy used by muscle to perform exercise
   - O True
   - O <u>False</u>
   - O Unsure

5. The protein recommendations for athletes are:
   - O A powder protein supplement is best
   - O Foods high in protein should be avoided since they are also high in fat
   - O Double the recommendations for the general population
   - O <u>Consuming a wide variety of foods in amounts to meet energy needs generally provides all the protein needed</u>

6. What is the **most important role** of protein in the body?
   - O <u>Aids tissue growth and maintenance</u>
   - O Provides immediate energy
   - O Keeps the hair, nails and skin healthy
   - O Boosts the immune function

7. Equivalent weights of carbohydrate and protein have approximately the same calories
   - O <u>True</u>
   - O False
   - O Unsure

SECTION I. THIS SECTION WILL ASK YOU ABOUT STRATEGIES FOR TRAINING AND FOOD CHOICES. PLEASE ANSWER ALL THE QUESTIONS AS BEST YOU CAN. EACH QUESTION/STATEMENT WILL HAVE ONE CORRECT ANSWER.

1. Taking confectionery (sweets, candy, jellies, lollies) before an event can improve exercise performance
   - O <u>True</u>
   - O False
   - O Unsure

2. The best time for an athlete who is training twice a day to eat after exercise is:
   - O <u>Within an hour</u>
   - O Within 2-3 hours
   - O It makes no difference
   - O Whenever the athlete feels hungry

3. The best pre-event meal (2-4 hours before) should be:
   - O Low in carbohydrate and fiber
   - O High in fat and low in carbohydrate and protein
   - O High in carbohydrate and low in fat and protein
   - O High in fiber and fat

4. Which would be the best food choice to consume after an intense resistance training session to maximize muscle building and start refueling?
   - O 75 g of pasta (5 tablespoons) in tomato sauce
   - O 75 g of white rice (5 tablespoons) with a green salad
   - O 2 small pancakes (120g) with honey
   - O 2 white bread rolls (100g) with cheddar cheese

5. Which of the following foods contains **50g of carbohydrate**:
   - O 70g raisins (4 tablespoons)
   - O 250ml of orange juice (1 glass)
   - O 250ml of an isotonic sports drink (1 glass)
   - O 125g yogurt (1 pot)

# APPENDIX B

## NUTRITIONAL SELF-EFFICACY QUESTIONNAIRE

## NUTRITIONAL SELF-EFFICACY QUESTIONNAIRE

Date:
ID#:

*Please **do not** write your name on this questionnaire.*

For each statement, please circle the number which best corresponds with your current belief:

| | Extremely confident | | | | Not confident at all |
|---|---|---|---|---|---|
| 1. I can choose foods which contain calcium on a daily basis. | 5 | 4 | 3 | 2 | 1 |
| 2. When I am hungry, I am able to eat healthy carbohydrate foods instead of snacks like candy bars, chips, and cookies. | 5 | 4 | 3 | 2 | 1 |
| 3. I am generally able to make healthy choices when ordering in a restaurant. | 5 | 4 | 3 | 2 | 1 |
| 4. I can select foods which are high in iron on a regular basis. | 5 | 4 | 3 | 2 | 1 |
| 5. I can usually choose foods which are low in fat. | 5 | 4 | 3 | 2 | 1 |
| 6. I am able to select foods which contain zinc. | 5 | 4 | 3 | 2 | 1 |
| 7. I am able to eat enough calories every day. | 5 | 4 | 3 | 2 | 1 |
| 8. I can select foods or beverages that will enhance the absorption of iron in the foods I eat. | 5 | 4 | 3 | 2 | 1 |
| 9. I am able to eat an adequate amount of protein on a regular basis. | 5 | 4 | 3 | 2 | 1 |
| 10. I can eat the right proportion of carbohydrates, fats, and protein on a daily basis. | 5 | 4 | 3 | 2 | 1 |

# APPENDIX C

## INTENTION SURVEYS

Name: ____________________
------------------------------------------------------------------------------------------------------------

Date: ID#:____________

**Directions:** Place a check (✓) in the blank that best indicates how you feel about the following statements.

| | Strongly Disagree | Strongly Agree |
|---|---|---|
| 1. I intend to eat a diet that would help me perform at my best. | I___I___I___I___I___I___I___I | |
| 2. I will try eating a healthy diet to help me perform at my best. | I___I___I___I___I___I___I___I | |
| 3. I plan on eating a healthy diet that would help me perform at my best. | I___I___I___I___I___I___I___I | |
| 4. It is very likely that I will eat a healthy diet that would help me perform at my best. | I___I___I___I___I___I___I___I | |

Name: ____________________
------------------------------------------------------------------------------------------------------------

Date: ID#:____________

**Directions:** Place a check (✓) in the blank that best indicates how you feel about the following statements.

| | Strongly Disagree | Strongly Agree |
|---|---|---|
| 1. Since our last meeting, I ate a healthy diet that would help me perform at my best. | I____I____I____I____I____I____I____I | |
| 2. I thought about changing my regular eating habits based on information from the education session(s). | I____I____I____I____I____I____I____I | |
| 3. I changed my regular eating habits based on information from the education session(s). | I____I____I____I____I____I____I____I | |