Georgia State University
ScholarWorks @ Georgia State University

Nutrition Theses
Department of Nutrition

8-11-2020

Dietary Intake, Nutrition Knowledge, and Body Composition of Collegiate Athletes: A Pilot Study

Jessica-Kim Danh

J. Andrew Doyle PhD, FACSM
Georgia State University

Anita M. Nucci PhD, RD, LD
Georgia State University

Rafaela G. Feresin PhD
Georgia State University

Follow this and additional works at: https://scholarworks.gsu.edu/nutrition_theses

Recommended Citation

Danh, Jessica-Kim; Doyle, J. Andrew PhD, FACSM; Nucci, Anita M. PhD, RD, LD; and Feresin, Rafaela G. PhD, "Dietary Intake, Nutrition Knowledge, and Body Composition of Collegiate Athletes: A Pilot Study." Thesis, Georgia State University, 2020.
https://scholarworks.gsu.edu/nutrition_theses/100

This Thesis is brought to you for free and open access by the Department of Nutrition at ScholarWorks @ Georgia State University. It has been accepted for inclusion in Nutrition Theses by an authorized administrator of ScholarWorks @ Georgia State University. For more information, please contact scholarworks@gsu.edu.

ACCEPTANCE

This thesis, [ENTER TITLE], by [ENTER STUDENT NAME] was prepared under the direction of the Master's Thesis Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree Master of Science in the Byrdine F. Lewis College of Nursing and Health Professions, Georgia State University. The Master's Thesis Advisory Committee, as representatives of the faculty, certify that this thesis has met all standards of excellence and scholarship as determined by the faculty.

____
[NAME]
Committee Chair

____
[NAME]
Committee Member

____
[NAME]
Committee Member

____
Date

AUTHOR'S STATEMENT

In presenting this thesis as a partial fulfillment of the requirements for the advanced degree from Georgia State University, I agree that the library of Georgia State University shall make it available for inspection and circulation in accordance with its regulations governing materials of this type. I agree that permission to quote, to copy from, or to publish this thesis may be granted by the professor under whose direction it was written, by the Byrdine F. Lewis College of Nursing and Health Professions director of graduate studies and research, or by me. Such quoting, copying, or publishing must be solely for scholarly purposes and will not involve potential financial gain. It is understood that any copying from or publication of this thesis which involves potential financial gain will not be allowed without my written permission.

____

Signature of Author

ABSTRACT

Background: Studies examining the dietary intake of collegiate athletes agree that common nutritional problems exists that put this population at high risk for nutrient and energy deficiencies. Additionally, nutrition knowledge deficit has been associated with improper dietary fueling in collegiate athletes. Furthermore, collegiate athletes often rely on coaches and athletic trainers for nutrition information, yet studies have shown that 64.1% of coaches and 28.6% of athletic trainers have inadequate nutrition knowledge.

Objectives: To assess nutritional intake, body composition, sports nutrition knowledge, and nutrition sources knowledge of NCAA Division I female volleyball players.

Methods: Nutritional intake was assessed using three-day food records during the pre-, during- and post-season while a 24-hour interview recall was used in the off-season. Daily average energy, carbohydrate, protein, fat, and specific vitamins and minerals intakes were analyzed using Food Processor 11.1. These values were compared to the recommendations from the American College of Sports Medicine (ACSM). Sports nutrition knowledge was assessed using an 87-question validated nutrition for sports knowledge questionnaire (NSKQ). Athletes were also asked to state their sources for nutrition knowledge. Body composition was assessed using bioelectrical impedance analysis.

Results: Fourteen female volleyball players (age: 19.6 ± 1.3 y, height: 69 ± 3 in, weight: 73 ± 8.5 kg, BMI: 24.1 ± 3 kg/m^2; body fat: 25 ± 3%) participated in this study in the pre-season with five having completed all four time-points. Athletes' mean energy intake across all 14 participants in the pre-season was 25 ± 6.4 kcal/kg BW/day, while carbohydrate, protein and fat intake were 3 ± 0.9, 1.3 ± 0.4, and 0.9 ± 0.3 g/kg BW/day, respectively. Vitamin D intake was 137 ± 91 IU/day and calcium intake was 673 ± 353 mg/day. Energy and carbohydrate intake were lower than the ACSM recommendations (37-41 kcal/kg BW/day and 6-10 g/kg BW/day, respectively). Protein intake fell within the recommended ranges (1.2-1.7 g/kg BW/day). Additionally, vitamin D and calcium were lower than their established recommendations. Likewise, the off-season dietary intake followed similar trends. The average NSKQ score was 45 ± 9.6%, which is below the adequate score of 75%, and was found to be positively associated with pre-season weight (r = 0.738, p = 0.003) and vitamin D intake (r = 0.587, p = 0.03). Four athletes included a registered dietitian nutritionist (RDN) as a source of nutrition information. In contrast, twelve athletes listed athletic trainers as a source.

Conclusions: The athletes in this study did not meet the established recommendations for adequate energy, carbohydrates, or select vitamins and minerals. Further, the athletes' average NSKQ scores reflect inadequate sports nutrition knowledge. Taken together with the information that the athletes' current nutrition knowledge is not wholly derived from professionals with the appropriate nutrition training, our team suggests that nutrition education provided by an expert in the field will improve dietary intake, health, and ultimately, sports performance.

Funding Sources: There are no funding sources.

Dietary Intake, Nutrition Knowledge, and Body Composition of Collegiate Athletes:

A Pilot Study

Jessica-Kim Danh

July 20, 2020

ACKNOWLEDGEMENTS

We thank our committee members Dr. Rafaela G. Feresin, Dr. Anita Nucci, and Dr. J. Andrew Doyle whose insights, expertise, and support greatly assisted in the completion of this study. Special thanks go to our family and friends whose emotional and moral support was invaluable throughout this endeavor.

This research was made possible with the cooperation of Coach Sally Schulte Polhamus and the Georgia State University Women's Volleyball team athletes, and we thank them for their time and commitment.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

1RM: One Repetition Maximum

Academy: Academy of Nutrition and Dietetics

ACSM: American College of Sports Medicine

BF%: Body Fat Percentage

BIA: Bioelectrical Impedance Analysis

BM: Body Mass

BMI: Body Mass Index

DRI: Dietary Recommended Intake

FM: Fat Mass

FFM: Fat-Free Mass

GPA: Grade Point Average

GSU: Georgia State University

ID: Identification

IU: International Unit

IQR: Interquartile Range

IRB: Institutional Review Board

NCAA: National Collegiate Athletic Association

NSKQ: Nutrition for Sports Knowledge Questionnaire

RDA: Recommended Daily Allowance

RDN: Registered Dietitian Nutritionist

RMANOVA: Repeated Measures of Analysis of Variance

SCC: Strength and Conditioning Coach

SD: Sports Dietitian

VDR: Vitamin D Receptor

YAQ: Youth Assessment Questionnaire

CHAPTER I

INTRODUCTION

1.1 Background and Significance

Collegiate athletes are a unique population for which nutrition and dietary habits play a pivotal role in growth, recovery, and performance. Not only do the demands for training, coursework, and scheduled game days contribute to a disordered dietary regimen, but the burden of financial resources and learning to cope with early adulthood add pressure to an already competitive life.[1] Previous studies examining the dietary intakes of collegiate athletes agree that there are common problems putting this population at high nutritional risk including low energy intake,[1,2,3] low carbohydrate intake, and high fat intake[2,3]. Furthermore, habits like skipping breakfast and inadequate hydration contribute to poor performance and fatigue[3]. Heaney *et al.*[4] reviewed nutrition knowledge among collegiate athletes and found that the level of knowledge is comparable among athletes and non-athletes. Moreover, Torres-McGhee *et al.*[5] reported in a cross-sectional study that athletes and coaches have a lower than average understanding of nutritional knowledge compared to athletic trainers and strength coaches. It should be noted that in the latter group, 28.6% of athletic trainers and 16.9% of strength coaches had inadequate nutrition knowledge.

Access to a sports dietitian (SD) who can provide evidence-based information and recommendations to athletes have been shown to improve issues with the gaps in knowledge regarding proper nutrition for performance.[1,6,7] For example, a common problem for athletes is planning their dietary intake during team trips. In a study that examined the dietary habits of National Collegiate Athletic Association (NCAA) Division

I baseball players who received their nutritional information from either a SD or a strength and conditioning coach (SCC), players seeing a SD consumed less fast food on team trips.[6] These players were also more likely to take multivitamins, found it easier to eat within two hours of activity, and were more likely to have a pre-workout meal or breakfast.

As of 2016, there were only 88 full-time SDs working in 61 universities with many being the sole SD for their entire school.[7] While there is a paucity of research examining the effects of having a SD on staff versus not, Hull *et al.*[7] reported in a separate study that athletes who do not meet directly with a SD may still benefit from their presence when they work as part of a multi-faceted team with the coaching staff. Further, in a control group study providing nutrition education to female collegiate athletes, Abood *et al.*[2] found that athletes receiving nutrition education reported greater self-efficacy and more confidence in their nutritional knowledge than athletes who did not.

While Georgia State University (Georgia State) boasts a home to 16 teams competing in the NCAA Division I, there is currently no SD providing evidence-based information to its athletes. Thus, we hypothesize that the lack of a dedicated nutrition expert will reflect poor nutrition knowledge and dietary intake in this population. The long-term goal of this study is to provide actionable information on the nutritional well-being of Georgia State athletes to further improve their performance and health. The main objectives of this study were to:

Objective 1: Assess the dietary intake of Georgia State women's volleyball athletes' pre-season, during season, post-season as well as off-season and compare them to the minimum recommendation for athletes. To achieve this aim, Georgia State collegiate athletes were asked to complete a web-based three-day food record four times throughout the study.

Objective 2: Identify nutrition resources among Georgia State women's volleyball athletes and assess their nutrition knowledge. To that end, athletes were asked to complete a web-based nutrition knowledge questionnaire at the beginning of the study.

Objective 3: Assess energy expenditure and body composition of Georgia State women's volleyball athletes' pre-season, during season, post-season as well as off-season. To achieve this aim, athletes were asked to complete a web-based physical activity questionnaire four times throughout the study and undergo body composition measurements four times throughout the study.

Data obtained from this study was used to identify the nutritional needs of athletes whether it be energy or nutrient deficiencies, education on nutrient periodization, proper hydration, and supplement usage. A general understanding of the current nutritional status of athletes will help coaches and trainers provide better support for their teams and thus, increase overall performance.

CHAPTER II

REVIEW OF THE LITERATURE

Proper nutrition and dietary habits play a pivotal role in the performance, recovery, and health of collegiate athletes.[8] Due to the rigorous demands of training, traveling, game days, and studying, however, collegiate athletes are often found to be at high nutritional risk.[1] These risks include, but are not limited to, low energy intake, low carbohydrate intake, high fat intake, and body image issues that may lead to restricted diets and undernutrition.[1-3,9] Furthermore, previous studies examining the dietary intake and nutrition knowledge of collegiate athletes suggest that a nutrition knowledge deficit is associated with improper dietary fueling.[3] Providing access to a SD who can properly disseminate evidence-based information to collegiate athletes has previously shown to improve the gap in knowledge regarding proper nutrition.[1,6,7] This review of literature will explore the collegiate athlete population to better understand the daily demands of their life and the consequences of improper dietary behavior, and then examine sports nutrition status of collegiate athletes in the following parts: Nutrition Intake and Knowledge, Body Composition, Sources of Nutrition Knowledge, and Nutrition Education Interventions.

2.1 Collegiate Athletes

Collegiate athletes competing in Division I of the NCAA must keep up with a demanding schedule both academically and athletically. According to the NCAA, eligibility requires that athletes maintain at least 90% of the minimum GPA required to graduate, six credit hours during a regular semester, and keep up with a set number of credit hours toward their degree each playable year (up to five years).[10] Similar eligibility requirements are seen for both Division II and Division III collegiate athletes. Additionally, athletes are expected to make time for practice sessions, which can be up to twice a day given the sport and time of year, training, travel, and game days. With a full schedule of daily events, athletes must also figure in times to eat and hydrate properly throughout the day. Given the diversity of universities in the United States, Hinton *et al.*[11] point out that it would be difficult to generalize dietary intakes of collegiate athletes due to differences in campuses, whether or not the athletes live in dormitories, and if athletes have access to facilities to purchase groceries and prepare foods. Studies agree, however, that collegiate athletes are not meeting their dietary needs to support their level of activity.[3,11-13]

The consequences of inadequate dietary fueling are many. As mentioned above, collegiate athletes are faced with stressors unseen in their non-athlete classmates. Mann *et al.*[14] found that across 101 Division I football players, there is a significant increase in physical injuries around examination periods due to stress. Coupled with deficiencies in energy and nutrient intake, athletes face reduced athletic performance due to loss of lean muscle mass, and potentially lost play-time from a reduction of immune system functions.[15] The American College of Sports Medicine (ACSM) recommends that athletes have a protein intake of 1.2 to 2.0 g/kg/d to support normal metabolic functions, recovery and remodeling, and protein turnover.[15] Without the consumption of adequate energy from carbohydrates, amino acids from protein will be oxidized and used for energy instead.[15] This inhibits protein synthesis, which is vital for all metabolic functions in the body, thus decreasing athletic performance.

A common nutritional deficiency seen in both male and female collegiate athletes is iron deficiency (both with and without anemia).[16] This is often due to inadequate intakes of iron along with other factors that might inhibit its absorption.[16] For example, a high consumption of teas, which contain tannins can inhibit iron absorption, and a diet low in red meat and vitamin C contribute to low iron intake as red meats are known to contain high amounts of iron while vitamin C promotes its absorption from plant sources.[16] Iron can also be depleted from hemolysis due to high physical activity, injury and rough physical contact.[12,16] Additional losses occur through the gastrointestinal and urinary tracts, from sweating, and menses.[12,16] Iron is critical to athletes because it is essential in the provision of oxygen to all tissues, including skeletal muscles – especially during exercise.[17] Inadequate iron intake essentially impairs aerobic capacity by inhibiting energy production, thus increasing reliance on anaerobic metabolism and decreasing performance.[17]

Another issue that leads to poor nutritional status in collegiate athletes is the prevalence of eating disorders among both females and males. In a survey of 1,455 NCAA athletes across 11 universities in 11 sports, Johnson *et al.*[18] identified 25% of the female sample as being at risk for anorexia nervosa with 9.5% of males at risk. Their criteria for identifying them as such were BMI $\leq$ 20 kg/m^2 or amenorrhea or elevation on either Drive for Thinness or Body Dissatisfaction eating disorder subscales. The authors also set a criteria for bulimia nervosa as having six episodes of binge eating or vomiting or laxative or diuretic abuse or use of diet pills or elevated scores of the previously mentioned eating disorder subscales, and found that 58% of female athletes and 38% of male athletes were at risk.

More studies have focused on eating disorders on female athletes due to the perceived pressures that being immersed in a culture where the body’s appearance and performance are of utmost importance and the standards of beauty are high.[19-21] In a study of 425 female athletes from seven NCAA universities in sports ranging from gymnastics, basketball, and golf, Beals *et al.*[22] found that the percentage of self-reported clinical diagnosis of anorexia nervosa was 3.3%, higher than the 1.96% reported by Johnson *et al*.[18] Additionally, almost 50% of the athletes in the study by Beals *et al.*[22] performed stated they were "terrified" of being overweight and nearly the same percentage admitted to restricting energy intake and limiting food choices to control their weight. This is in agreement with another study that surveyed 219 female collegiate gymnasts and 106 female swimmers across the United States that found the most common method of weight control was exercising two or more hours per day and dieting.[21] Other studies examining the prevalence of eating disorders among female athletes agree that the health risks associated with them are costly and can lead to other illnesses.[23] As Greenleaf *et al.*[19] state, this includes imbalances in electrolytes, dehydration, depression, decreased bone density, and cardiac arrhythmia. While detrimental to performance, these are serious illnesses that should be addressed with proper intervention from professionals.

Female collegiate athletes are further susceptible to what is known as the female athlete triad which is a combination of low energy with or without disordered eating, amenorrhea, and premature osteoporosis.[22,24] This condition is applied to female athletes who exhibit one or more of the criteria described. Tenforde *et al.*[24] investigated the prevalence of female athlete triad at their university across 16 sports and classified them as low-, medium-, or high-risk according to the 2014 Female Athlete Triad Coalition guidelines. They found that 29% of their athletes were medium to high risk and note that these results will help identify athletes at risk of bone stress fractures. Bone stress fractures can become detrimental to sports as it pulls the athlete out of play, not only affecting their training regimen but the team as a whole.

Quatronomi[1] referenced other common challenges that collegiate athletes face that relate to nutritional issues. These include, but are not limited to, chronic dieting, maladaptive coping mechanisms, pressures of the sports and academic environment, and difficulties adjusting to the college lifestyle.[1] These challenges are important to consider given their impact on nutrition, performance, and health.

2.2 Nutrition Intake of Collegiate Athletes

Due to the demands of training, the caloric and nutrient needs of collegiate athletes are often higher than the Recommended Dietary Allowance (RDA), which is an average daily intake that is sufficient to meet the requirements of 97% to 98% of healthy people.[8] Studies agree, however, that the nutrition intake of collegiate athletes is less than optimal with many athletes failing to meet the energy and nutrient requirements to support their level of activity.[11-13,25,26] According to the ACSM, this can result in such consequences like loss of muscle mass, menstrual dysfunction for female athletes, decreased bone density, increased risk of injury, and increased time to recover.[15]

In a study examining the dietary habits of female collegiate athletes, 45 participants across different sports completed a three-day food record and had the nutrients compared to their estimated energy needs.[3] The reported intakes revealed that the participants' energy intakes were significantly lower than the estimated energy required ($p < 0.001$), and 91% did not meet energy needs.[3] The same study also measured the nutritional habits of these female collegiate athletes across all sports and found that 36% reported consuming less than five meals per day with 29% consuming less than three. Further, breakfast was only regularly consumed by 27% of the participants. The athletes also reported that they dined out 5.4 times per week at sandwich shops (31%), Mexican restaurants (29%), and fast food restaurants (20%). This number is higher than one reported in Division III football players in which they reported dining out 2.5 times per week, of which 71% were at fast food or fast casual restaurants.[27]

The energy intake reported in the above study is in contrast to what Hinton *et al.*[11] found when surveying the intakes of both male and female collegiate athletes. Hinton *et al.*[11] separately reported the intakes of males and females and stated that the mean energy intake for female athletes reached the recommended level for those who participate in light-to-moderate activity. It should be noted, however, that Hinton *et al.*[11] utilized the Youth Assessment Questionnaire (YAQ), which is a food frequency questionnaire validated for use with 9- to 18-year old individuals but that the average age of their participants were 19.5 years for males and 19.3 years for females. Further, the sports that recruited athletes played spanned across 13 types including track and field, soccer, gymnastics, and golf, and so using "light-to-moderate" activity may have been a conservative estimate of how much energy athletes use. In males, Hinton *et al.*[11] reported that the mean energy intake was approximately 400 kcal below the recommended level for males who participate in light-to-moderate activity. For carbohydrates and proteins, both male and female athletes failed to meet their recommended levels. Similarly, Rash *et al*.[28] found that the diet quality for male and female collegiate track athletes were "healthy," but they followed similar methods to Hinton *et al.* in using the YAQ for an older population.

In the study examining dietary intakes of Division III football players, Abbey *et al.*[27] found that these athletes met their requirements for energy, monounsaturated fats, and protein. The composition of other nutrients, however, shows room for improvement. Total carbohydrates, dietary fiber, and total polyunsaturated fats were below the recommended levels while total fat, saturated fat, dietary cholesterol, sodium, and potassium were all high.[27] This is important to consider because nutrient composition of diet is just as critical as meeting energy requirements for athletes.

One such nutrient that has increasingly been examined in recent years is vitamin D. Vitamin D is a fat-soluble vitamin that acts as a steroid hormone and plays a critical role to maintain homeostasis between calcium and phosphorous levels.[29] Further, the binding of the activated form of vitamin D, known as calcitriol, to intracellular vitamin D receptor (VDR) regulates gene expression and is involved in over 900 physiological processes.[29] Thus, vitamin D is not only important for bone health, but it is essential for normal bodily processes. In fact, deficiencies in vitamin D have been associated with reduced immune function as well as diseases such as cardiovascular disease.[29] For collegiate athletes whose stress from academics and training are high, prolonged deficiency of vitamin D can negatively affect performance. In a controlled trial of 24 professional male and female ballet dancers, of which only 15% had normal levels of vitamin D, supplementation of vitamin D over four months improved muscular strength by 19% and power by 7.2% while the control group saw no change in muscular strength and a 2% decline in power.[30] Muscular strength was assessed by a five-second isometric quadricep contraction, and muscular power was assessed by vertical jump.[30] While this contradicts the findings of Carswell *et al.*[31] who did not see an increase in strength or power among a randomized trial of 137 male military recruits, Carswell *et al.* did find a positive association between endurance performance and vitamin D status among 967 male and female recruits utilizing at 1.5-mile run for measure baseline and follow-up. It should be noted that differences in power and strength found in these two studies may be due to the level of athleticism of the groups used. The first mentioned recruited professional dancers while in the latter, they studied military recruits, but their level of training was not specified.

As previously mentioned, vitamin D is important in the homeostasis of blood calcium levels. While calcium is often associated with its critical role in bone health, it is also crucial in muscle contraction as well as glucose metabolism. Therefore, a deficiency in calcium by lack of intake or by vitamin D deficiency may prove detrimental for an athlete's performance and health. In a study of 72 elite female athletes of different sports backgrounds, Heaney *et al.*[32] found that 36% of athletes failed to meet the RDA for calcium. Other micronutrients for which athletes did not meet the RDA were folate (70%), iron (51%), and magnesium (35%).[32]

2.3 Nutrition Knowledge of Collegiate Athletes

A foundation in sports nutrition knowledge is an important first step for athletes to improve their dietary patterns and intake. While many athletes understand the importance of nutrition and that it is an integral part of their program, their education on healthy nutritional practices and application of those practices is inadequate.[33] Nutrition knowledge alone and its association with dietary intake was recently found to have a weak positive correlation among collegiate athletes.[4,33] Despite this, researchers agree that the inconsistencies in the reported correlation strengths may be due to the numerous factors involved transforming nutrition knowledge to behavior and that having more nutrition knowledge does not negatively impact intake in this population.[4,27] Thus, the provision of nutrition knowledge for sports to athletes remains vital.

Heaney *et al.*[4] identified 19 studies that assessed nutrition knowledge and dietary intake among athletes (elite or otherwise) with only nine of those studies investigating an association between knowledge and intake. Just two of these studies included participants on a collegiate team: in their 1992 study, Frederick and Hawkins compared nutrition knowledge and practices among postmenopausal women, female college-aged dancers, female collegiate track members, and nonathletic college-age women, and found that nutrition knowledge was significantly correlated with the number of high-calcium food servings consumed.[34] Additionally, they found that the track members had a significantly higher mean score for anorexia and bulimia than did the other comparison groups.[34] Rash *et al.*[28] also studied collegiate track members across two Division I universities, and utilized the YAQ to gather data on dietary intake and a previously constructed nutrition knowledge questionnaire to measure knowledge and attitude. They reported a weak correlation between dietary intake quality and nutrition knowledge ($r = 0.001$) as well as little correlation between knowledge and particular nutrients: carbohydrates ($r = 0.011$), protein ($r = -0.009$), vitamin C ($r = -0.004$), and vitamin E ($r = -0.005$).[28] Outside of the United States, a study from Nigeria examined the correlation between nutrition knowledge and energy intake of athletes at their university and agreed that there is a weak positive correlation.[33]

It should be noted that while there is no gold standard sports nutrition knowledge questionnaire, several studies were found to have used the same tool. Other studies examining nutrition knowledge used their own questionnaire or a modification of other tools such as the General Nutrition Knowledge Questionnaire. The questionnaires implemented in these studies cover the same general topics such as macronutrient and micronutrient needs, supplement use and efficacy, weight management, hydration, and alcohol use as it relates to sports.

In studies concerning the nutrition knowledge of collegiate level athletes researchers agree that the nutrition knowledge of the majority is inadequate.[4,9,27,35-37] Heaney *et al.*[4] found common misconceptions in their review including athletes believing that "protein acts as a primary energy source for muscle contraction," that supplementing vitamins and minerals will provide energy, and that supplementation of vitamins, minerals, and protein were key to ensuring peak performance. Indeed, in the studies since Heaney *et al.* published their systematic review, several have come out in agreement with their findings. Torres-McGehee *et al.*[9] designed and validated their own sports nutrition knowledge questionnaire and found that athletes had below-average scores. In particular, their research team found that the overall lowest average was on the topic of micronutrients and macronutrients with second lowest on weight management and eating disorders, and the topic with the highest average was on supplements and performance.[9] Four years later, Andrews *et al.* used the sports nutrition knowledge questionnaire developed by Torres-McGehee *et al*.[35] in their own study and also found that their student athlete population (N=123) had inadequate knowledge. Their average score was 56.9% where adequacy was defined as a score of at least 75% correct responses – only 12 students achieved adequacy.[9] Further, the average score of students who had inadequate knowledge was 54%.[9] Abbey *et al.* also used the same questionnaire tool on Division III football players and found that their mean score of 55.2% was comparable to previous reports but also noted that athletes who had taken a nutrition course in the past performed better than those who did not.[27]

2.4 Sources of Nutrition Knowledge

Outside of the classroom, collegiate athletes spend much of their time in training and practice with coaches and athletic trainers. As staple figures during their collegiate careers it is no surprise that it is them who they turn to for advice on performance, strategy, and nutrition.[6,27,35,38] While there is no question as to the expertise of coaches and trainers to improve their athletes at play, there begs the question as to the adequacy of their nutrition knowledge.

A sports nutrition knowledge questionnaire distributed by Torres-McGehee *et al*.[5] found that 91% (n=161) of athletes had inadequate nutrition knowledge. These same athletes' top three resources for nutrition knowledge are their SCC, athletic trainers, and their coach.[5] After taking the same questionnaire, however, results revealed 64.1% inadequacy of nutrition knowledge in coaches, 28.6% in athletic trainers, and only 16.9% in SCC.[5] Overall, the results of this study revealed that the participants had below-average nutrition knowledge. This agrees with another study that assessed the knowledge of coaches and athletic trainers at a Division I university finding that across all 53 respondents, participants responded correctly to only 67% of the nutrition-related questions.[39] Furthermore, a 2004 survey of 236 collegiate athletes listed athletic trainers and SCCs as their primary sources of nutrition information at 39.8% and 23.7%, respectively.[38] Given the reliance on coaches and trainers, it is important that this group receive adequate nutrition education for sports and performance to disseminate accurate information to their athletes.

A previous study conducted in 1991 surveyed 430 collegiate athletes from Division I universities and found that magazines were the most popular source of nutrition information.[40] While this is no longer the case, internet media has crept up alongside athletic trainers and parents as a popular source of nutrition information among collegiate athletes.[41] In another study of 88 Division III football players, 21% indicated that websites were a source of their nutrition information.[27] This was the second highest source with coach being the first at 25%.[27] Without proper training in understanding nutrition research and sorting fact from fiction in the media, however, collegiate athletes may fall prey to fad diets and inaccurate diet tips they may find in social media.

A Certified Specialists in Sports Dietetics is a registered dietitian nutritionist (RDN) who has been certified in the United States and Canada and has been given additional credentials as a sports nutrition experts.[8] They are recognized as the experts who understand the intricacies of nutrition, athletic culture, physiology, and stresses that college athletes face.[1] Studies have shown that nutrition education provided by RDNs have positive outcomes on the nutrition knowledge of both collegiate athletes and the general public.[7] As of 2016, however, there are only 88 full-time RDNs working as the SD within 61 schools that are a part of a major college conference.[7] In many cases, these SDs are the only ones servicing the athletes at their schools which can range from 350-600 collegiate athletes.[7]

In one of the few studies examining the impact of a SD on dietary behavior of athletes, Hull *et al.*[6] compared the use of a SD versus SCC on baseball teams in three institutions (two of which employed a SD). They found that athletes with access to a SD had more favorable outcomes in dietary behavior than those who did not.[6] For example, athletes seeing a SD were more likely to not have caffeinated drinks, eat fast food, or drink soda.[6] Additionally, they were more likely to use a multivitamin, eat within 1-2 hours of training or competition, prepare their own meals at least three times a week, and eat a pre- and post-workout snack or meal.[6] While performance results were not reported in this study, it reveals the importance of a SD on improving healthful dietary behaviors on athletes.

2.5 Body Composition of Collegiate Athletes

Body composition can have a profound impact on sports performance,[42,43] especially in those sports where leanness is encouraged like track and field, wrestling, and gymnastics; even increased mass is encouraged in sports such as football. Indeed, a study on 98 competitive male sprinters for the 100 m race participated in a study out of Croatia that suggested significant differences in sprinting performances can be seen in the participants who are less ectomorphic, have greater fat-free mass, and more strength.[44] This agrees with another study from Qatar that measured senior male soccer players' anthropometrics against their performance and repeated-sprint ability.[45] They reported that higher muscular profiles and lower adiposity were associated with higher repeated-sprint ability – an important factor for soccer players.[45]

In collegiate athletes, body composition varies from sport-to-sport, across the season, and even within different positions of the same sport. A large study measured the body compositions of 475 male and female Division I athletes, evaluating one time point across five years to catalog data for specific sports and their positions.[42] The authors used air-displacement plethysmography to measure body fat percentage (BF%), fat mass (FM), fat-free mass (FFM), and body mass (BM).[42] Their findings in both men's soccer and men's track and field agree with the two studies from Croatia and Qatar that low BF% and a low FM:FFM ratio is most advantageous to their sport given body fat may negatively impact the power-to-weight ratio and decrease performance.[42] These two groups were also found to have the lowest BF% and FM:FFM when compared to the other sports.[42] The men's baseball group had the highest FM:FFM with the authors suggesting that it is due to the lack of endurance necessary for the sport.[42] It should be noted that football was not a group that was measured for this study. In women's sports, women's track and field had the lowest BF%, FM, BM, and FM:FFM when compared to other groups.[42] Similar to the reasons given above for men's track and field, the authors suggest this is likely influenced by the need to have speed and jump height to increase performance.[42] Among the other women's teams (lacrosse, soccer, and swimming), there were no difference in the body composition measurements.[42] Women's volleyball had no observable differences in composition to women's swimming but was higher than women's track and field in BF% and higher than lacrosse and soccer in BM.[42] The authors further note that due to volleyball's emphasis on power output, low BF% is not necessary in their sport.[42]

This same study also compared different sport positions. In men's soccer, they found that goal keepers had higher levels of body composition when compared to defenders, midfielders, and forwards, but that the latter three had no observable differences among them.[42] This is similar to their findings on women's lacrosse in which their goal keepers also had higher levels of body composition compared to the field positions likely owing to their need to remain around the goal posts.[42] In women's volleyball, they found that athletes in the middle blocker positions had the highest FFM and BM when compared to other positions due to their need to both attack and block the ball.[42]

Stanforth *et al.*[43] measured the body composition of Division I female athletes across multiple sports (soccer, track, volleyball, basketball, and swimming), over the seasons, and over multiple years. Agreeing with the above research, they found that track athletes had the lowest BF% when compared to other sports ($p < 0.05$). From preseason to postseason, basketball players had decreased their BM, FM, and BF% significantly while soccer players saw no changes across any measurements. In both swimming and track, they saw a decrease in FM and BF% while lean mass increased. For volleyball players, they saw a significant increase in lean body mass. The latter also seems to agree with Fields *et al.*[42] given the emphasis on power output, it would seem the team focused on training that would increase their FFM. Finally, the authors followed their athletes over three years to measure changes in body composition. While they saw no significant changes for soccer or track, they did see changes in the other sports. Swimmers saw an increase in lean mass between year one to year three, and volleyball players saw an increase each year in lean mass.[43] There was an increase in BF% from year one to year three in basketball players as well as an increase in FM which, according to the authors, may be atypical given it did not agree with their previous findings.[43]

In a study measuring the body composition and bone density of female collegiate soccer players across three time points in a season, Minett *et al.*[46] saw a decrease in lean mass and an increase in BF% over the course of the seasons which contradicts the findings above that saw no changes in soccer players' body composition variables. The authors suggest this may be due to the change in training schedules in which the players had three days of strength training in the preseason and only one during the competitive season. They also speculate that the changes may be due to negative energy balance, but because the players did not complete their food diaries, they did not have sufficient data to report this. The authors also saw no significant changes in bone measurements across the seasons, but this is not surprising given the short time frame in which the measurements were taken; i.e. there were three months between the first two measurements and six months between the second and third.

Trexler *et al.*[47] measured the body composition of Division I football players over the course of a season and their collegiate careers and found favorable changes to body composition over a calendar year with BF% decreasing and lean mass increasing across participants. They saw the same favorable changes over the career of their participants and report similar changes in magnitude between lineman and non-linemen. While the authors state that their findings differ from others found in literature, they state this may be owing to the fact that their freshman cohort was ranked top 25 in the country and may have been more well-prepared for sport than those of other universities who had been researched. It should also be considered that the Hawthorne effect may have been at play in which athletes altered their behavior to improve outcomes because they were aware they were being measured and that this may be true for many longitudinal studies.

As mentioned, body composition plays a significant role in the performance of collegiate athletes, but few observational studies include the dietary component in the measurements.

2.6 Nutrition Education Intervention

There is a paucity of research on the impact of nutrition education intervention on collegiate athletes. While it was mentioned earlier that there is a weak positive correlation between nutrition knowledge and dietary intake,[4,33] studies associating the two were few and those specifically looking at collegiate athletes were fewer.

Valliant *et al.*[13] evaluated the dietary intake and nutrition knowledge of female volleyball athletes during two off-seasons and sought to find if a nutrition education intervention would improve both intake and knowledge. During the intervention season, the athletes met with a RDN four times for an individualized nutrition intervention session based on their needs and to provide education. The study found that, on average, the athletes failed to meet the energy, carbohydrate, protein, and fat needs during both off-seasons.[13] There were, however, statistically significant improvements seen between the two seasons. During the initial off-season, energy intake averaged 1,756 kcal/day and saw 0% of athletes at energy balance while the end of the intervention season saw an increase in energy intake to 2,178 kcal/day and 18% of athletes at energy balance ($p = 0.002$). Additional improvements were seen in intakes of carbohydrate ($p = 0.01$) and protein ($p = 0.01$), and nutrition knowledge ($p = 0.001$).

Another similar study by Abood *et al.*[2] examined the impact of nutrition education intervention using Social Cognitive Theory provided to one female sports team (soccer) but not the other (swimming). The study was designed as a pretest-posttest and found that there were statistically significant improvements in the nutrition knowledge questionnaire and self-efficacy questionnaire in the experimental group ($p < 0.05$) with no changes to the control group.[2] The authors also report that there were more positive dietary changes in the experimental group than the control.[2]

In one study of Division I baseball players, sports nutrition education was given to the players as an intervention to measure its effects on body composition and performance.[48] Prior to and after the intervention, participants were measure for body composition, filled out three-day food diaries, and had their sports nutrition knowledge assessed.[48] Additionally, performance testing was carried out using shuttle tests, vertical jump, broad jump, and 1 repetition maximum (1RM) of the back squat. Rossi *et al.*[48] found that the intervention group saw increases in nutrition knowledge as well as nutrition status, and that, when compared to the control group, the intervention group had a greater reduction in BF% and total FM, greater increase in lean mass, and improved performance in shuttle times. While these results are promising for nutrition education for athletes, it should be noted that the study had a small sample size of 15 athletes.

While the studies just described show promising trends in providing nutrition education to improve dietary behaviors of collegiate athletes, the common theme across this review is glaring: collegiate athletes are lacking in nutrition knowledge and proper dietary behaviors to support their performance at play and in the classroom. It is important to understand the gap in knowledge and diet so that their needs may be addressed and supported.

CHAPTER III

METHODS AND PROCEDURES

3.1 Participants

Following approval of this study by the institutional review board (IRB) of Georgia State, recruitment of participating collegiate athletes was conducted through the team coaches, student athlete director, and via email blast to Georgia State female volleyball athletes. Inclusion criteria included student athletes actively participating on the Georgia State female volleyball team from Summer 2019- Summer 2020 and 18 years of age or older. Only athletes who were eligible for intercollegiate competition during the academic year were included.

3.2 Contacting Participants

The research team had a minimum of six initiating contact emails with the participants. Due to the nature of the study, should the participants have questions or conflicting dates for their appointments, there was more contact. The research team reached out to participants for the following reasons:

- Recruitment of Georgia State athletes along with date and time of information session.
- Information Session Follow-Up with Link to Consent Form: The research team provided electronic copies of the materials covered in the information session along with a link to the consent form.

- Two weeks prior to each time point: The research team provided a link to the three-day food record, a copy of the food record packet, and set an agreed upon appointment for body composition and physical activity assessments.

3.3 Health History

Once consent was received (see **Appendix 1** for consent form), participants were asked to fill out and submit a health history form (see **Appendix 2**) that included, but was not limited to, any current or past joint issues, surgical history, and allergies.

3.4 Dietary Intake

Participating athletes agreed to provide a three-day food record at four time points throughout the study: pre-season, during season, post-season, and off-season. The post-season was considered the time immediately after tournaments had ended while the off-season was approximately two months after post-season. During each time point, participants had the option of submitting an electronic log of their food record or filling out a physical packet and submitting it to the research team. See **Appendix 3** for food record packet. For either method of entry, the participants were asked to record the date and time of the entry, the food and its description, the amount consumed, and record two weekdays and one weekend day. Additionally, participants were asked to be specific as possible, as well as include if the item consumed was just before, during, or after a training/exercise session. At the start of the study, participants were given instructions during a group meeting with the research team that included explanation on how to fill out a food record as well as how to estimate portion sizes using everyday objects. Analysis of the three-day food record was performed using a food analysis software (Food Processor version 11.1, ESHA Research).

The electronic food log was distributed through the research team's secure Google Forms account. Participants were encouraged to bookmark the link on their browser and phone for ease of access, and forms could be submitted multiple times. There were four separate links for each time point. The required fields included: Study identification (ID) number, Date, Time, Item Consumed, and Amount Consumed. There was also an optional Notes section should participants wish to add any comments about their entry, e.g. "consumed before practice." For participants filling out the food record packet, they submitted these records to the research team upon their body composition appointment for that time point.

To increase participation rates during the off-Season time period, researchers obtained approval from the IRB to conduct in-person 24-hour food recalls with athletes. These interviews took place at the same appointment for body composition and physical activity assessment.

3.5 Nutrition Knowledge Questionnaire

During the pre-season time point, nutrition knowledge was assessed using the Nutrition for Sports Knowledge Questionnaire (NSKQ) developed by Trakman *et al.*[49] from La Trobe University, Melbourne Victoria Australia. See **Appendix 4** for questionnaire. The questionnaire was previously validated and covers topics such as macronutrients, micronutrients, supplements, and alcohol consumption.[49] Permission to distribute and utilize this questionnaire in this study was obtained. Some modifications were made to the NSKQ by the research team. They were as follows:

- Unit measurements to describe quantities of food have been updated to reflect more standard uses in the United States population. For example, describing protein in ounces (oz) rather than grams (g).
- Two sections have been added onto the NSKQ: Nutrition Resources and Demographics and Other. These sections are not meant to assess nutrition knowledge, but rather collect valuable data from participating athletes.

In total, there are 87 questions and estimated time for completion is 25 minutes. The NSKQ was distributed to participating athletes via weblink to Qualtrics.com, an online survey application through Georgia State.

3.6 Body Composition and Physical Activity Assessment

During each of the aforementioned time points, participating athletes reported to Petit Science Center 454 for body composition measurements. Height was measured using a Perspective Enterprises stadiometer (Portage, Michigan), and weight and body fat percentage was measured using a Tanita BC-418 bioelectrical impedance analysis device (BIA) (TANITA Corporation of America Inc., Arlington Heights, Illionois). This is a noninvasive measurement device in which participants stood without shoes and socks on a platform and held two handles out to their sides for thirty seconds. Participants were instructed to also remove any heavy or baggy clothing prior to stepping onto the device. Measurement values were recorded under the participant's Study ID Number. See **Appendix 5** for body composition data collection form.

After measurements were complete, the research team used a physical activity questionnaire to ask participants a series of questions to assess their level of activity during that timepoint. These questions address the number of times the participants have trained in the last week, the intensity perceived during those sessions, the length and frequency of those sessions, as well as any workout sessions done outside of regular practice. See **Appendix 6** for physical activity data collection form.

3.7 Ethical Considerations

There were no discomforts associated with the protocols of this study. Participants had access to the research team via email, phone, and text should they have any questions or concerns. If at any point the participant was unwilling to continue in the study, they could withdraw.

3.8 Data Management Plan

Participants's data were de-identified and assigned unique numbers. Briefly, after athletes had consented to participate in this study, the research team provided a unique Study ID Number to each participant that they used for the remainder of the study. The file that identifies each Study ID Number to the participant's names was kept in a locked cabinet in the office of Dr. Rafaela G. Feresin in Urban Life 871.

The data generated in this study was primarily digital data generated from online surveys. The data were collected and stored digitally in excel files and statistical analysis software. The digital data are stored on Georgia State's secure OneDrive account to prevent data degradation or loss. Only the PI, and the student PI has access to the data stored in the OneDrive account.

3.9 Data Analysis

Descriptive statistics were calculated for all variables. Distribution of outcome variables was examined graphically for symmetry and outliers using histograms. Extreme outliers were investigated for technical or clerical errors and such values were eliminated. Normality was determined using Shapiro-Wilk tests. Data are reported as mean ± standard deviation (SD) for normally distributed variables and median and interquartile range (IQR) for non-normally distributed variables. Paired-Sample t-tests were used to compare the means of normally distributed data while Wilcoxon signed-ranks tests were used to compare non-normally distributed variables. Repeated measures for body composition were analyzed using repeated measures analysis of variance (RMANOVA) for normally distributed variables. If a significant F-ratio was obtained, Bonferroni post hoc test were used for pairwise comparisons. Friedman two-way analysis of variance was used to analyze non-parametric data. Non-repeated measures such as dietary intake was compared to minimum recommendations. Pearson correlation coefficients (r) were calculated between nutrition knowledge scores, dietary intake and body composition and Spearman R was used for the correlation of non-normally distributed data. Statistical significance was defined as $p < 0.05$. Data analyses was performed using IBM SPSS Statistics for Windows version 26.0 (IBM Corp., Armonk, N.Y., USA).

CHAPTER IV

RESULTS

4.1 Participants

Fourteen female athletes from women's volleyball (mean age: 19.6 ± 1.3 y) participated in the study at the pre-season and during-season time points. At post-season, two athletes were lost to follow-up while one athlete reported an unrelated illness and could not attend the appointment. At off-season, the athlete reporting ill had returned but another six athletes were lost to follow-up. Athletes denied history of high blood pressure, high cholesterol, Type 1 Diabetes, Type 2 Diabetes, hypoglycemia, and liver or renal complications. However, two athletes reported history of skeletal/joint disorders. Two athletes reported changes in their diets over the last 6 months. All athletes denied smoking.

4.2 Dietary Intake

All 14 participants submitted three-day food records during the pre-season. The results are displayed in Table 1. On average, participants consumed 1,791 ± 450 kcal, 217 ± 64 g of carbohydrates, 92 ± 35 g of protein, and 64 ± 19 g of fat in the pre-season. Based on the dietary recommended intakes (DRI) established by the National Academies of Sciences, Engineering, and Medicine, the participants did not meet the recommendations for the following vitamins and minerals: vitamin A (568 ± 388 mcg), vitamin D (137 ± 91 IU), folate (281 ± 127 mcg), calcium (674 ± 2345 mg), iron (16 ± 8 mg), and potassium (1813 ± 619 mg). Among the 12 participants for which thiamin intake appeared to be within normal limits, the median intake was 0.8 (0.65, 1.1) mg which falls below the DRI for thiamin.

Athletes failed to provide enough meaningful data for the three-day food records for the during-season and post-season timepoints. While some athletes began the process for recording, only three athletes fully completed their records for both seasons resulting in the research team's omission of the during- and post-season dietary intake data. For the off-season timepoint, the researchers administered a 24-hour recall among the remaining six participants. On average, participants consumed 2,610 ± 820 kcal, 312 ± 110 g of carbohydrates, 124 ± 33 g of protein, and 99 ± 38 g of fats in the off-season. The participants failed to meet the DRIs for the following vitamins and minerals: vitamin B6 (2.3 ± 1.3 mg), vitamin D (358 ± 541 IU), folate (324 ± 237 mcg), and potassium (1842 ± 536 mg). **Table 1** displays the means from the pre-season three-day food record and the off-season 24-hour recall, as well as the recommended dietary intakes for each nutrient. Comparison of means determined that cholesterol ($p = 0.003$, 95% CI [-637.1, -162.1]) and sodium ($p = 0.05$, 95% CI [-3896.0, -49.0]) intake were significantly different between the pre- and off-season.

Table 1. Average daily intake for athletes recorded via three-day food record in pre-season and 24-hour recall in off-season.

Nutrient	Pre-Season Intake (n=14)	Off-Season Intake (n=6)	Recommended Intake
Calories (kcal)	1791 ± 450	2610 ± 820	2707 - 3000*
Carbohydrates (g)	217 ± 64	312 ± 110	439 - 731*
Protein (g)	92 ± 35	124 ± 33	87 - 124*
Fat (g)	64 ± 19	99 ± 38	60 - 117*
Saturated Fat (g)	22 ± 7	31 ± 20	< 15
Cholesterol (mg)	358 ± 196	758 ± 380#	< 300
Vitamin A (mcg)	568 ± 388	752 ± 830	700
Vitamin B1 (mg)	0.8 (0.65, 1.1)	1.2 ± 0.86	1.1
Vitamin B2 (mg)	1.2 ± 0.70	1.5 ± 1.0	1.1
Vitamin B3 (mg)	29 ± 15	17 ± 10	14
Vitamin B6 (mg)	1.5 (1.1, 1.9)	2.3 ± 1	1.3
Vitamin B12 (mcg)	4.5 ± 4	6.0 ± 5	2.4
Vitamin C (mg)	87 ± 56	122 ± 59	75
Vitamin D (IU)	137 ± 91	358 ± 541	600
Folate (mcg)	281 ± 127	324 ± 237	400
Calcium (mg)	764 (366, 959)	1052 ± 525	1000
Iron (mg)	14 (10, 18)	23 ± 14	18
Phosphorous (mg)	740 ± 307	970 (710, 1120)	700
Potassium (mg)	1813 ± 619	1842 ± 536	2600
Sodium (mg)	2467 ± 721	4588 ± 159#	< 2300

Data are pooled and summarized as mean ± standard deviation for normally distributed data and as median (interquartile 25%, 75%) for non-normally distributed data.

# Indicates statistical difference between means with $p < 0.05$.

Kcal refers to kilocalories; g refers to grams; mg refers to milligrams; mcg refers to micrograms; IU refers to international units; * refers to recommendations given by the American College of Sports Medicine. Recommendations made based on female needs where appropriate.

4.3 Nutrition for Sports Knowledge Questionnaire Scores

Scores of 75% or more indicate adequate sports nutrition knowledge while scores below this threshold are considered inadequate.[5] **Table 2** provides mean percentage scores for the NSKQ overall, as well as for each of its sections. The NSKQ raw mean score was 39.1 ± 7.9, which equaled a percent score of 45.4 ± 9.6%. The highest overall percent score was 64.4% while the lowest was 33.3%. Participants performed the best in the Macronutrients subsection with a score of 53.6 ± 1.9% with poorest results in the Supplementation subsection with a score of 32.1 ± 4.7%.

Table 2. Nutrition for Sports Knowledge Questionnaire (NSKQ) scores.

	Percent Score (%)
Overall NSKQ	45.4 ± 10
Macronutrient Section	53.6 ± 7
Micronutrient Section	45.6 ± 13
Sports Nutrition Section	38.7 ± 22
Supplementation Section	32.1 ± 18
Alcohol Section	50.0 (37.5, 50)

Data are pooled and summarized as mean ± standard deviation for normally distributed data and as median (interquartile 25%, 75%) for non-normally distributed data.

4.4 Sources of Nutrition Knowledge

Participants were asked where they received their nutrition information by selecting from a list of sources. The most selected source of nutrition information was athletic trainer (n=12) with SCC and nutritionist following up at nine selections each. Only four participants selected RDN. Participants were also asked to choose their top three sources of nutrition information from those they had selected previously. Five participants did not answer this section. **Table 3A** and **Table 3B** depicts the complete list of nutrition information sources, as well as the number of times each were selected. Participants were also provided an opportunity to select "Other" and fill in a source of nutrition information that was not listed, however, no participant chose this option.

Table 3A. Athletes' chosen sources for nutrition information.

Nutrition Information Source	No. of Times Chosen (N=14)
Athletic Trainer	12
Strength & Conditioning Coach	9
Nutritionist	9
Family	7
Internet Search	6
Coach	5
Social Media	5
Registered Dietitian	4
Friends	2
Nurse	1
Physician	1
Teammates	1
Scientific Articles	1
Books & Magazines	1
Physical Therapist	0

Table 3B. Nutrition information sources selected in the top three choices.

Nutrition Information Source	No. of Times Chosen (n=9)
Athletic Trainer	8
Nutritionist	6
Internet Search	3
Registered Dietitian	2
Family	2
Coach	1
Strength & Conditioning Coach	1
Social Media	1
Nurse	0
Physician	0
Physical Therapist	0
Teammates	0
Scientific Articles	0
Books & Magazines	0
Physical Therapist	0

No. refers to number.

4.5 Body Composition and Physical Activity Assessment

All 14 participants presented themselves for body composition and physical activity assessments at the pre-season and during-season timepoints while 11 and six were present for the post-season and off-season, respectively. **Table 4** displays the average body weight (BW), BMI, and BF% at each timepoint. Only five participants presented themselves for each of the four timepoints. Forward mean imputation was performed on the body composition values for the post- and off-seasons and the all updated values tested normal (data not shown). RMANOVA showed a non-significant change in body weight (p = 0.380), height ($p = 0.09$) and BMI ($p = 0.7$). A significant change was found in BF% and the Bonferroni post hoc analysis revealed significant differences in BF% between during-season and post-season ($p = 0.003$) and during-season and off-season ($p = 0.004$).

Table 4. Body composition assessments at each timepoint.

Measurement	Pre-Season (n=14)	During-Season (n=14)	Post-Season (n=12)	Off-Season (n=6)
Weight (lb)	161 ± 19	162 ± 19	163 ± 21	174 ± 15
Height (in)	69 ± 3	69 ± 3	69 ± 3	71 ± 1
Body Fat (%)	25 ± 3	24 ± 3	26 ± 4	26 (23, 30)
BMI (kg/m^2)	24 ± 3	24 ± 2	24 ± 3	24 ± 2

Data are pooled and summarized as mean ± standard deviation for normally distributed data and as median (interquartile 25%, 75%) for non-normally distributed data.

Lb refers to weight in pounds; in refers to inches; % refers to percent; BMI refers to body mass index in kilograms (kg) per meters (m) squared (^{2}).

Participants were also asked to report the number and average duration of training sessions that they participated in the last seven days during their assessment. Additionally, participants reported the average number of sessions that felt intense, moderate, or easy. Sessions included conditioning, weight training, and skills practice. **Table 5** displays the means for each time timepoint as reported by the athletes. RMANOVA with Greenhouse-Geisser correction determined that mean number of training sessions ($F(1.509, 6.035) = 12.649$, $p = 0.009$), intense sessions ($F(2.040, 8.162) = 13.594$, $p = 0.002$), and average training duration ($F(1.026, 4.103)=13.290$, $p=0.02$) differed statistically between time points (data not shown). Bonferroni post hoc test revealed statistically significant changes in the number of training sessions between the pre-season and post-season ($p = 0.01$) and the during-season and post-season ($p = 0.001$), number of intense sessions between the pre-season and during-season ($p = 0.4$), and the average duration between pre-season and post-season ($p = 0.4$).

Table 5. Training sessions at each timepoint.

	Pre-Season (n=14)	**During-Season (n=14)**	**Post-Season (n=12)**	**Off-Season (n=6)**
No. of Training Sessions	4 ± 2	7 ± 2	0.1 ± 0.3	5 ± 3
No. of Intense Sessions	2 ± 2	3 ± 2	0.1 ± 0.3	3 ± 3
No. of Moderate Sessions	2 ± 2	3 ± 2	0	3 ± 2
No. of Easy Sessions	0.4 ± 1	0.7 ± 0.3	0	0.1 ± 0.3
Average Duration (min)	58 ± 39	111 ± 29	4 ± 12	68 ± 40

Data are pooled and summarized as mean ± standard deviation for normally distributed data and as median (interquartile 25%, 75%) for non-normally distributed data.

No. refers to number; min refers to minutes.

4.6 Comparisons

Correlations were made between NSKQ percent scores (overall and for each subsection), nutrition information sources, pre-season body composition, and dietary intake. Significant positive correlations were found between overall NSKQ percent score and weight (r = 0.738, *p* = 0.003), vitamin B2 (riboflavin) intake (*r* = 0.625, *p* = 0.02), and vitamin D intake (*r* = 0.587, *p* = 0.03). Pre-season weight was also found to have positive significant correlations with weight management score (*r* = 0.676, *p* = 0.008), micronutrient score (*r* = 0.708, *p* = 0.005), sports nutrition score (*r* = 0.591, *p* = 0.03), and

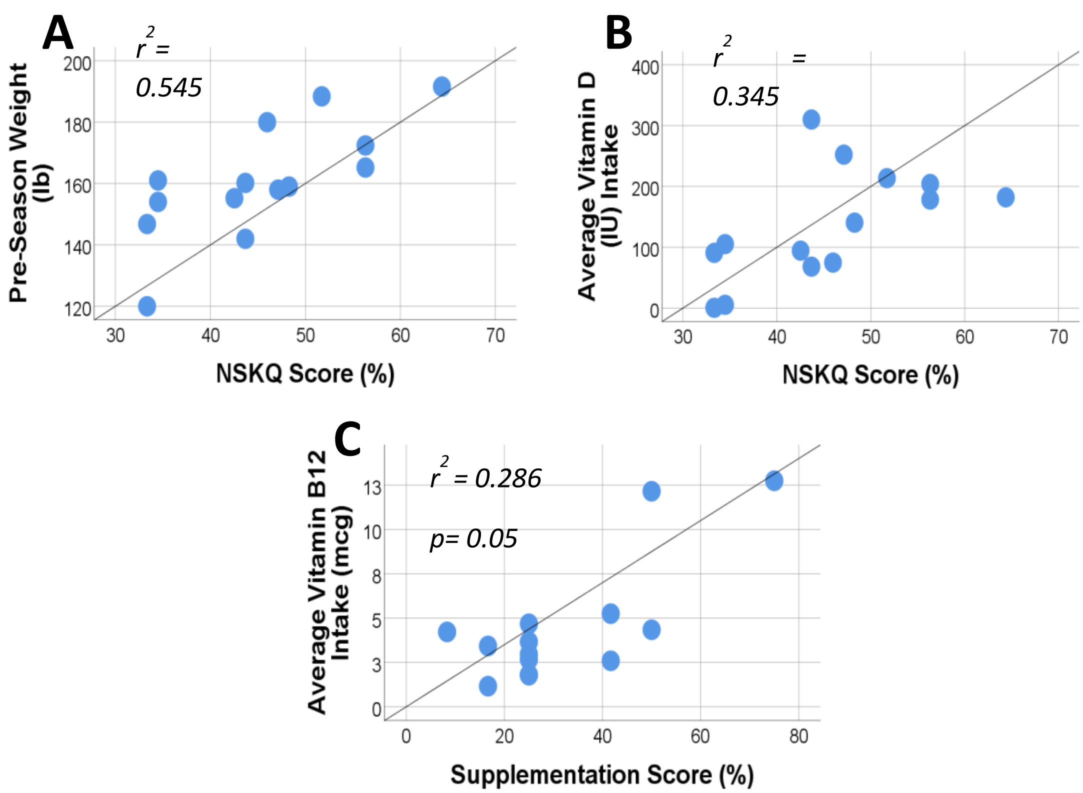


Figure 1. Correlations found between Nutrition for Sports Knowledge Questionnaire (NSKQ) scores and pre-season dietary intake. Figure 1.A shows positive correlation between weight and NSKQ score. Figure 1.B shows positive correlation between average vitamin D intake and NSKQ score. Figure 1.C shows positive correlation between vitamin B12 intake and supplementation score. Significance was set to $p < 0.05$. lb refers to weight in pounds; IU refers to international units; mg refers to milligrams; mcg refers to micrograms; % refers to percent.

supplementation score (*r* = 0.538, *p* = 0.05), but not macronutrient score (*p* = 0.07) or alcohol score (*p* = 0.8). Supplementation score had a significant positive correlation with intake of riboflavin (*r* = 0.535, *p* = 0.05) and vitamin B12 (*r* = 0.762, *p* = 0.002).

CHAPTER V

DISCUSSION

The first objective of this study was to examine the dietary intake of collegiate athletes and compare them to the current nutrition recommendations throughout seasons. We show that, on average, participating athletes failed to meet the recommendations for energy and carbohydrates for physically active females. Despite the increase in caloric intake from pre- to off-season, athletes fell below the recommended energy recommendation of 37-41 kcal/kg/day.[50,51]

Additionally, the mean carbohydrate intake for the participating athletes fell below the recommendation of 6-10 g/kg BW/day in both the pre- and off-season.[15] These findings agree with previous studies examining the dietary intake of collegiate athletes demonstrating a need to improve their dietary habits.[1-3,6,9,27,37] According to the ACSM and Academy of Nutrition and Dietetics (Academy), athletes with persistent low energy intake may exhibit loss of muscle mass, sub-optimal bone density, increased risk of injury, and prolonged recovery time.[15] Furthermore, female athletes are at risk of menstrual disturbances when energy intake is ≤ 30 kcal/kg BW/day.[51] Low energy intake may also suggest poor micronutrient intake. The present study found that athletes did not meet the DRI values for vitamin A, thiamin, vitamin D, folate, calcium, iron, and potassium in the pre-season and vitamin B6, vitamin D, folate, and potassium in the off-season. While poor intake of certain micronutrients may lead to deficiencies, the constant over consumption of others may lead to a host of other chronic diseases. Thus, the increased intake of saturated fat, cholesterol, and sodium should be noted in this population. These values agree with the previous studies by Abbey *et al.*[27] and Hinton *et al.*[11]

Differences in the pre- and off-season dietary intake may be due to the change in data collection method. Due to the lack of participation in the online three-day food records for the during- and post-seasons, the research team administered 24-hour dietary recalls in the off-season to reduce the burden on athletes and increase participation. While athletes confirmed that their recall reflected a typical day of eating, the change in collection method may not allow for an accurate comparison of dietary intake between seasons.

The second objective of this study was to assess the sports nutrition knowledge of athletes using the NSKQ and to identify their sources of nutrition knowledge. All participating student-athletes had inadequate NSKQ scores having scored below the 75% threshold for adequacy. Our results fall below the average scores for participants both with (64.65%) and without (52%) nutrition education as reported by Trakman *et al.*[49]. However, the results follow a similar trend when it comes to NSKQ section scores. For example, the macronutrient section score had the highest average while the supplements section had the lowest average.[49] These scores are consistent with previous assessments of sports nutrition knowledge of collegiate athletes.[5,27,35,37] Although the tools used to assess sports nutrition knowledge among athletes was different in the aforementioned studies, most questionnaires covered similar topics such as macronutrients and micronutrients, supplementation, and weight management.

Few studies have examined the relationship between nutrition knowledge and dietary intake among collegiate athletes. In a systematic review of 29 articles, Heaney *et* *al.*[4] found nine studies that investigated the association between dietary intake and nutrition knowledge. Of those studies, five reported a weak, positive ($r < 0.44$) association between knowledge and better dietary intake.[4] Our study found similar results in which higher NSKQ scores correlated with higher intake of vitamin D and riboflavin. While calorie intake was not significantly correlated with NSKQ scores, weight in the pre-season was positively correlated with NSKQ scores, which may suggest that athletes with more nutrition knowledge more frequently consumed adequate energy and thus, weighed more.

Interestingly, when section mean scores were compared with dietary intake, the supplement section score had a significant, positive correlation with riboflavin and vitamin B12. The supplements section on the NSKQ covered both the use of micronutrient supplements, as well as the use and safety of ergogenic aids, which suggests that the participating athletes are not well-informed on such topics. Given the strict guidelines for the use of supplements and performance-enhancing drugs in the NCAA, it is imperative for student-athletes to be aware of what is safe and permitted for consumption.[15]

Participants identified athletic trainers as the top selection in the two questions asking to select all sources of nutrition information and selecting the top three sources. This finding agrees with previous reports in which athletic trainers are often a source for nutrition information among athletes.[5,27,52,53] This is likely due to the frequency in which athletes and athletic trainers interact with one another during practice, allowing for a comfortable relationship to form. Indeed, in a survey of athletic trainers regarding their experiences counseling collegiate athletes, Moulton *et al.*[52] reported that athletic trainers often felt their roles go beyond prevention and care of athletic injuries with "nutritionist" being one of the top roles and "eating disorders" as a frequent topic of discussion.

Furthermore, the athletic trainers in Moulton *et al.'s* study identified themselves as "safe" and "approachable" allowing for a "special relationship" with athletes, but only five of the 14 participants felt adequately trained to counsel.[52]

While our study found no significant correlation between the source of nutrition information and overall NSKQ percent scores, the inadequate sports nutrition knowledge results coupled with the failure to meet energy and carbohydrate needs may indicate a need to evaluate the nutrition knowledge of those working closely with the athletes and to provide proper nutrition support. In fact, Torres-McGehee *et al.*[5] reported that 28.6% of athletic trainers and 64.1% of coaches had inadequate nutrition knowledge. Another study interviewing varsity coaches from a Canadian university reported that coaches will provide athletes sports nutrition advice despite having low nutrition knowledge scores themselves.[5,54]

Registered Dietitian Nutritionists are board certified to provide nutrition counseling and education to individuals and in group settings. Only four participants selected that they received nutrition information from a RDN with two participants listing a RDN as one of their top three sources for nutrition information while nine athletes chose nutritionist as a source of information and six listed it as a top three source. It should be noted that the questionnaire did not clarify the difference between the roles of RDN and nutritionist, and there may be speculation as to whether the athletes are aware of their distinction. According to the Academy, RDNs are nutrition experts that have completed a minimum of a bachelor's degree, have completed 1200 hours of supervised practiced, passed a national examination administered by the Commission on Dietetic Registration, and continue to complete professional educational requirements to maintain their credentials.[55] The laws governing the practice of nutrition counseling vary from state-to-state and may require that the individual be credentialed to obtain licensure for practice. For example, in the state of Georgia, food and nutrition practitioners must be credentialed as a RDN to obtain state licensure. Other states like California, Texas, and New York allow any individual to call themselves "nutritionist" to perform nutrition counseling but not medical nutrition therapy. This may include food bloggers, Instagram influencers, or trainers at a local gym.

Valliant *et al*.[13] reported that education provided by a RDN improved dietary intake and nutrition knowledge in NCAA female volleyball players over the course of two off-seasons. Briefly, participants' dietary intakes were recorded via three-day food records at the beginning and end of the first off-season, and once a month during the second off-season while individualized dietary education (intervention) took place.[13] Participants also completed the Reilly and Maughan sports nutrition knowledge questionnaire at the beginning and end of the intervention period.[13] While dietary recommended intake for energy was not fully met, participants showed significant increases in total energy, carbohydrate, and protein, as well as a significant increase in sports nutrition knowledge.[13] These results demonstrate a valuable role in nutrition education by a certified nutrition expert. This is in contrast to the findings of our study which demonstrate that when the primary source of nutrition information is a non-nutrition expert, nutrition knowledge and dietary intake are inadequate. Indeed, Hull *et al.*[6] reported that baseball players at universities with an employed SD were more likely to use a multivitamin supplement, practice proper dietary habits around training and consume less caffeinated drinks, soda, and fast food on team trips.

The third objective of this study was to assess body composition and physical activity at each timepoint. Mean BMI at each time point were within normal range and weight and BF% did not change significantly throughout the study. In fact, the average weight and BF% for each timepoint was consistent for women's volleyball as reported in a study examining body composition of athletes.[42] While BF% of these players is higher than what is typically seen in other sports, women's volleyball's emphasis on power output demands a reliance on body size, thus the findings in these assessments are within normal limits for their sport.[42]

During the physical activity assessment, athletes reported the number of training sessions they had attended in the last seven days. The during-season timepoint sessions were reportedly the highest with 6.8 sessions per week while post-season was the lowest with 0.09 sessions per week. The off-season saw an increase to 5.0 training sessions per week. Athletes reported that most training sessions felt moderately to highly intense. Given the frequency of training sessions and level of intensity, inadequate energy and carbohydrate intake may compromise sport performance. While exercise may be fueled by a combination of non-oxidative pathways (phosphagen and glycolytic) and oxidative pathways (carbohydrate and fat oxidation), the latter acts as the primary pathway for events lasting longer than two minutes.[15] Carbohydrates, in particular, may act as a substrate in both anaerobic and oxidative pathways allowing for its use in a wide range of intensities.[15] Moreover, carbohydrates provide a greater yield of adenosine triphosphate per volume of oxygen that can be delivered to the mitochondria, making them more advantageous over fats as a fuel source.[15] Thus, adequate consumption of energy and macronutrients is important in the performance of athletes.

Limitations

An underlying objective of this study was to determine the feasibility of collecting such data from athletes across multiple seasons at a university by understanding the limitations. The first limitation is the declining participation rate throughout the study. The research team was able to assess body composition and physical activity of all athletes in the pre- and during-season timepoints, but participation dropped significantly by the end as athletes became unresponsive to emails to make appointments. Furthermore, athletes failed to complete three-day food records in the during- and post-season timepoints, which prevented the research team from evaluating this valuable data and prompted the switch to a 24-hour dietary recall taken during the body composition and physical activity assessment at the final timepoint. The switch in data collection is another limitation as it prevents a meaningful comparison between timepoints. Future studies may benefit from setting strict dates for appointments, as well as using a mobile bioelectrical impedance device to meet athletes at the training hall before practice.

Another limitation was the process of collecting three-day food records. While athletes were reminded to be specific, the lack of details for some entries made it difficult to determine the correct nutrient amounts. Additionally, the research team did not follow-up on records immediately after submission, which prevented the chance for clarification. While the 24-hour recall interview provided a setting conducive to discussions that could clarify questions on the athletes' diets, future studies would benefit from using an application-based diet record that would allow athletes to query a large database for their specific food items, which would make it easier to export nutrient data as well.

Lastly, body composition measurements may have been affected by fluids and exercise posing another limitation to this study as best practice dictates that measurements via BIA should only be performed following the restriction of fluids, caffeine intake, food, and exercise.[56] Due to training and course schedules, however, this may be a persistent issue as proper fueling and hydration should take precedence.

Conclusion

This study revealed that athletes in this population have inadequate sports nutrition knowledge as well as inadequate energy, carbohydrate, and key micronutrient intakes. In the absence of a nutrition expert, these findings lead our team to reject the null hypothesis. Nutrition can have positive effects on athletic performance and recovery by inducing metabolic adaptations to improve training and reduce the risk of injury, thereby necessitating the need to improve dietary habits.[53] These improvements may be brought on by increasing nutrition knowledge as even a weak correlation between knowledge and diet may translate into physical benefits for athletes. Taken together, these results suggest that collegiate athletes may benefit from nutrition education and counseling provided by RDNs. Athletes and coaches alike are often looking for a competitive edge, thus it is imperative that they have a source that provides evidence-based nutrition information and proper dietary counseling to enhance performance and recovery while reducing the risk of disease and injury.

REFERENCES

1. Quatromoni PA. Clinical observations from nutrition services in college athletics. *J Am Diet Assoc.* 2008;108(4):689-694.
2. Abood DA, Black DR, Birnbaum RD. Nutrition education intervention for college female athletes. *J Nutr Educ Behav.* 2004;36(3):135-137.
3. Shriver LH, Betts NM, Wollenberg G. Dietary intakes and eating habits of college athletes: are female college athletes following the current sports nutrition standards? *J Am Coll Health.* 2013;61(1):10-16.
4. Heaney S, O'Connor H, Michael S, Gifford J, Naughton G. Nutrition knowledge in athletes: a systematic review. *Int J Sport Nutr Exerc Metab.* 2011;21(3):248-261.
5. Torres-McGehee TM, Pritchett KL, Zippel D, Minton DM, Cellamare A, Sibilia M. Sports nutrition knowledge among collegiate athletes, coaches, athletic trainers, and strength and conditioning specialists. *J Athl Train.* 2012;47(2):205-211.
6. Hull MV, Neddo J, Jagim AR, Oliver JM, Greenwood M, Jones MT. Availability of a sports dietitian may lead to improved performance and recovery of NCAA division I baseball athletes. *J Int Soc Sports Nutr.* 2017;14:29.
7. Hull MV, Jagim AR, Oliver JM, Greenwood M, Busteed DR, Jones MT. Gender differences and access to a sports dietitian influence dietary habits of collegiate athletes. *J Int Soc Sports Nutr.* 2016;13:38.
8. Thomas DT, Erdman KA, Burke LM. Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance. *J Acad Nutr Diet.* 2016;116(3):501-528.
9. Torres-McGehee TM, Monsma EV, Dompier TP, Washburn SA. Eating disorder risk and the role of clothing in collegiate cheerleaders' body images. *J Athl Train.* 2012;47(5):541-548.
10. Association NCA. Division I Progress-Toward-Degree Requirements. 2020.
11. Hinton PS, Sanford TC, Davidson MM, Yakushko OF, Beck NC. Nutrient intakes and dietary behaviors of male and female collegiate athletes. *Int J Sport Nutr Exerc Metab.* 2004;14(4):389-405.
12. Noda Y, Iide K, Masuda R, et al. Nutrient intake and blood iron status of male collegiate soccer players. *Asia Pac J Clin Nutr.* 2009;18(3):344-350.
13. Valliant MW, Emplaincourt HP, Wenzel RK, Garner BH. Nutrition education by a registered dietitian improves dietary intake and nutrition knowledge of a NCAA female volleyball team. *Nutrients.* 2012;4(6):506-516.
14. Mann JB, Bryant KR, Johnstone B, Ivey PA, Sayers SP. Effect of Physical and Academic Stress on Illness and Injury in Division 1 College Football Players. *J Strength Cond Res.* 2016;30(1):20-25.

15. Thomas DT, Erdman KA, Burke LM. American College of Sports Medicine Joint Position Statement. Nutrition and Athletic Performance. *Med Sci Sports Exerc.* 2016;48(3):543-568.

16. Gropper SS, Blessing D, Dunham K, Barksdale JM. Iron status of female collegiate athletes involved in different sports. *Biol Trace Elem Res.* 2006;109(1):1-14.

17. Hinton PS. Iron and the endurance athlete. *Appl Physiol Nutr Metab.* 2014;39(9):1012-1018.

18. Johnson C, Powers PS, Dick R. Athletes and eating disorders: the National Collegiate Athletic Association study. *Int J Eat Disord.* 1999;26(2):179-188.

19. Greenleaf C, Petrie TA, Carter J, Reel JJ. Female collegiate athletes: prevalence of eating disorders and disordered eating behaviors. *J Am Coll Health.* 2009;57(5):489-495.

20. Ashley CD, Smith JF, Robinson JB, Richardson MT. Disordered eating in female collegiate athletes and collegiate females in an advanced program of study: a preliminary investigation. *Int J Sport Nutr.* 1996;6(4):391-401.

21. Thompson A, Petrie T, Anderson C. Eating disorders and weight control behaviors change over a collegiate sport season. *J Sci Med Sport.* 2017;20(9):808-813.

22. Beals KA, Manore MM. Disorders of the female athlete triad among collegiate athletes. *Int J Sport Nutr Exerc Metab.* 2002;12(3):281-293.

23. McLester CN, Hardin R, Hoppe S. Susceptibility to eating disorders among collegiate female student-athletes. *J Athl Train.* 2014;49(3):406-410.

24. Tenforde AS, Carlson JL, Chang A, et al. Association of the Female Athlete Triad Risk Assessment Stratification to the Development of Bone Stress Injuries in Collegiate Athletes. *Am J Sports Med.* 2017;45(2):302-310.

25. Karpinski CA, Milliner K. Assessing Intentions to Eat a Healthful Diet Among National Collegiate Athletic Association Division II Collegiate Athletes. *J Athl Train.* 2016;51(1):89-96.

26. Hinton PS, Beck NC. Nutrient intakes of men and women collegiate athletes with disordered eating. *J Sports Sci Med.* 2005;4(3):253-262.

27. Abbey EL, Wright CJ, Kirkpatrick CM. Nutrition practices and knowledge among NCAA Division III football players. *J Int Soc Sports Nutr.* 2017;14:13.

28. Rash CL, Malinauskas BM, Duffrin MW, Barber-Heidal K, Overton RF. Nutrition-related knowledge, attitude, and dietary intake of college track athletes. *The Sport Journal.* 2008;11(1):48-54.

29. Bizzaro G, Antico A, Fortunato A, Bizzaro N. Vitamin D and Autoimmune Diseases: Is Vitamin D Receptor (VDR) Polymorphism the Culprit? *Isr Med Assoc J.* 2017;19(7):438-443.

30. Wyon MA, Koutedakis Y, Wolman R, Nevill AM, Allen N. The influence of winter vitamin D supplementation on muscle function and injury occurrence in elite ballet dancers: a controlled study. *J Sci Med Sport.* 2014;17(1):8-12.

31. Carswell AT, Oliver SJ, Wentz LM, et al. Influence of Vitamin D Supplementation by Sunlight or Oral D3 on Exercise Performance. *Med Sci Sports Exerc.* 2018;50(12):2555-2564.

32. Heaney S, O'Connor H, Gifford J, Naughton G. Comparison of strategies for assessing nutritional adequacy in elite female athletes' dietary intake. *Int J Sport Nutr Exerc Metab.* 2010;20(3):245-256.

33. Folasire OF, Akomolafe AA, Sanusi RA. Does Nutrition Knowledge and Practice of Athletes Translate to Enhanced Athletic Performance? Cross-Sectional Study Amongst Nigerian Undergraduate Athletes. *Glob J Health Sci.* 2015;7(5):215-225.

34. Frederick L, Hawkins ST. A comparison of nutrition knowledge and attitudes, dietary practices, and bone densities of postmenopausal women, female college athletes, and nonathletic college women. *J Am Diet Assoc.* 1992;92(3):299-305.

35. Andrews A, Wojcik JR, Boyd JM, Bowers CJ. Sports Nutrition Knowledge among Mid-Major Division I University Student-Athletes. *J Nutr Metab.* 2016;2016:3172460.

36. Gilis J.T. ADL, Morgan A.L. and Hamady C.M. Nutrition Knowledge and Interest of Collegiate Athletes at a Division I University. *J Food Nutr.* 2014;1:7.

37. Rosenbloom CA, Jonnalagadda SS, Skinner R. Nutrition knowledge of collegiate athletes in a Division I National Collegiate Athletic Association institution. *J Am Diet Assoc.* 2002;102(3):418-420.

38. Burns RD, Schiller MR, Merrick MA, Wolf KN. Intercollegiate student athlete use of nutritional supplements and the role of athletic trainers and dietitians in nutrition counseling. *J Am Diet Assoc.* 2004;104(2):246-249.

39. Smith-Rockwell M, Nickols-Richardson SM, Thye FW. Nutrition knowledge, opinions, and practices of coaches and athletic trainers at a division 1 university. *Int J Sport Nutr Exerc Metab.* 2001;11(2):174-185.

40. Jacobson BH, Gemmell HA. Nutrition Information Sources of College Varsity Athletes. *The Journal of Strength & Conditioning Research.* 1991;5(4):204-207.

41. Zuniga KE, Downey DL, McCluskey R, Rivers C. Need for and Interest in a Sports Nutrition Mobile Device Application Among Division I Collegiate Athletes. *Int J Sport Nutr Exerc Metab.* 2017;27(1):43-49.

42. Fields JB, Merrigan JJ, White JB, Jones MT. Body Composition Variables by Sport and Sport-Position in Elite Collegiate Athletes. *J Strength Cond Res.* 2018;32(11):3153-3159.

43. Stanforth PR, Crim BN, Stanforth D, Stults-Kolehmainen MA. Body composition changes among female NCAA division 1 athletes across the competitive season and over a multiyear time frame. *J Strength Cond Res.* 2014;28(2):300-307.

44. Barbieri D, Zaccagni L, Babic V, Rakovac M, Misigoj-Durakovic M, Gualdi-Russo E. Body composition and size in sprint athletes. *J Sports Med Phys Fitness.* 2017;57(9):1142-1146.

45. Brocherie F, Girard O, Forchino F, Al Haddad H, Dos Santos GA, Millet GP. Relationships between anthropometric measures and athletic performance, with special reference to repeated-sprint ability, in the Qatar national soccer team. *J Sports Sci.* 2014;32(13):1243-1254.

46. Minett MM, Binkley TB, Weidauer LA, Specker BL. Changes in body composition and bone of female collegiate soccer players through the competitive season and off-season. *J Musculoskelet Neuronal Interact.* 2017;17(1):386-398.

47. Trexler ET, Smith-Ryan AE, Mann JB, Ivey PA, Hirsch KR, Mock MG. Longitudinal Body Composition Changes in NCAA Division I College Football Players. *J Strength Cond Res.* 2017;31(1):1-8.

48. Rossi FE, Landreth A, Beam S, Jones T, Norton L, Cholewa JM. The Effects of a Sports Nutrition Education Intervention on Nutritional Status, Sport Nutrition Knowledge, Body Composition, and Performance during Off Season Training in NCAA Division I Baseball Players. *J Sports Sci Med.* 2017;16(1):60-68.

49. Trakman GL, Forsyth A, Hoye R, Belski R. The nutrition for sport knowledge questionnaire (NSKQ): development and validation using classical test theory and Rasch analysis. *J Int Soc Sports Nutr.* 2017;14:26.

50. American College of Sports M, American Dietetic A, Dietitians of C. Joint Position Statement: nutrition and athletic performance. American College of Sports Medicine, American Dietetic Association, and Dietitians of Canada. *Med Sci Sports Exerc.* 2000;32(12):2130-2145.

51. Volek JS, Forsythe CE, Kraemer WJ. Nutritional aspects of women strength athletes. *Br J Sports Med.* 2006;40(9):742-748.

52. Moulton MA, Molstad S, Turner A. The role of athletic trainers in counseling collegiate athletes. *J Athl Train.* 1997;32(2):148-150.

53. Holden SL, Forester BE, Keshock CM, Williford HN. Sports Nutrition Knowledge of Volleyball Players. *International Journal of Kinesiology in Higher Education.* 2019;3(2):58-65.

54. Danaher K, Curley T. Nutrition Knowledge and Practices of Varsity Coaches at a Canadian University. *Can J Diet Pract Res.* 2014;75(4):210-213.

55. Dietetics AoNa. What is a Registered Dietitian Nutritionist. 2013.

56. Carrion BM, Wells A, Mayhew JL, Koch AJ. Concordance Among Bioelectrical Impedance Analysis Measures of Percent Body Fat in Athletic Young Adults. *Int J Exerc Sci.* 2019;12(4):324-331.

APPENDICES

Appendix 1

Georgia State University

Department of Nutrition

Informed Consent

Title: Assessing Dietary Intake, Nutrition Knowledge, and Body Composition of Collegiate Athletes

Principal Investigator: Dr. Rafaela G. Feresin

Student Principal Investigator: Jessica-Kim Danh

I. Introduction and Key Information:

You are invited to take part in a research study. It is up to you to decide if you would like to take part in the study. The purpose of this study is to learn about the nutrition knowledge, food intake, and body composition of Georgia State University (GSU) college athletes. You are invited to participate in this study because you are a Division I athlete at GSU, who is 18 years of age or older.

Your role in the study will last 8 hours over a 6-month time period.

You will be asked to do the following: attend a first meet-and-greet to get to know the research team and what we are doing, meet with the research team 4 times to assess your body composition, fill out a 3-day food record 4 times, fill out a physical activity form 4 times, fill out a Health and Fitness History form once, and fill out a Nutrition for Sports Knowledge Questionnaire once.

Participating in this study will not expose you to any more risks than you would experience in a typical day.

This study is designed to benefit you. You may gain valuable insight into your dietary needs to improve your sports performance and health. Overall, we hope to gain information about the dietary habits and nutrition-related knowledge of collegiate athletes at Georgia State University so that athletes, coaches, and trainers can act on improving overall health and performance.

II. Purpose:

The purpose of this study is to learn about the nutrition knowledge, food intake, and body composition of Georgia State University (GSU) college athletes. You are invited to participate in this study because you are a Division I athlete at GSU, who is 18 years of age or older. A total of 400 student athletes will be invited to take part in this study.

III. Procedures:

To participate in this study, you will begin by giving consent. This will be done by submitting a form online.

If you decide to take part, you will complete an online three-day food record four times (pre-season, during season, post-season, and off-season). Alternatively, you may fill out a three-day food record packet by hand and turn it into the research team at the time of your body composition appointment. After you complete each food record, the researchers will review them and reach out to you if they have any questions about it. You will also complete three separate online surveys about nutrition, your health and fitness history, and your physical activity. The nutrition survey and health and fitness history form will be completed once at the start of the study. The physical activity form will be completed at each of the four time points.

You will also meet the researchers at Petit Science Center 454 for height, weight and body composition measurements four times (pre-season, during season, post-season, and off-season) during the study. Body composition will be measured using bioelectrical impedance machine (BIA). This machine requires that you stand on it without shoes and socks and hold a handle in each hand for approximately 30 seconds.

The study will take place over a 6-month period and you will have contact with the research team at least 4 times once the study begins. At each of these time points, the activities required of you will take approximately 2 hours. Please refer to the table for a simple view of the activities and timetable.

Activity	Pre-Season	During Season	Post-Season	Off-Season
Body Composition Measurement	X	X	X	X
Three-Day Food Record	X	X	X	X
Physical Activity Form	X	X	X	X
Health and Fitness History	X			
Nutrition for Sports Knowledge Questionnaire	X			

All your information will be kept confidential. You will be given a study code number, and only that code number (not your name) will be used on the forms. This will make sure that the results of these tests cannot be traced back to you by anyone not on this study research team.

IV. <u>Future Research:</u>

Researchers will remove information that may identify you and may use your data for future research. If we do this, we will not ask for any additional consent from you.

V. Risks:

In this study, you will not have any more risks than you would in a normal day of life. No injury is expected from this study, but if you believe you have been harmed, contact the research team as soon as possible. Georgia State University and the research team have not set aside funds to compensate for any injury.

VI. Benefits:

This study is designed to benefit you. You may gain valuable insight into your dietary needs to improve your sports performance and health. Overall, we hope to learn about the dietary habits and nutrition-related knowledge of collegiate athletes at Georgia State University so that athletes, coaches, and trainers can act on improving overall health and performance.

VII. Alternatives:

The alternative to taking part in this study is to not take part in the study.

VIII. Voluntary Participation and Withdrawal:

You do not have to be in this study. If you decide not to be in the study and change your mind, you have the right to drop out at any time. You may skip questions or stop participating at any time. Your coaches and trainers will not be informed if you do or do not take part in this study. You may refuse to take part in the study or stop at any time. This will not cause you to lose any benefits to which you are otherwise entitled.

IX. Confidentiality:

We will keep your records private to the extent allowed by the law. The following people and entities will have access to the information you provide:

- Dr. Rafaela G. Feresin (Principal Investigator) and Jessica-Kim Danh (Student Principal Investigator)
- GSU Institutional Review Board
- Office of Human Research Protection (OHRP)

We will use a study number rather than your name on study records. The information you give will be stored on password-protected computers that use 2-step verification procedures to access their files. Additionally, the survey and forms you submit to the research team are hosted on secure websites with password protection. The key code sheet that identifies your name to the study number will be kept separately from the digital files and will be stored in a locked cabinet in the office of Dr. Rafaela G. Feresin on GSU's campus in the Urban Life building. This key will be destroyed six months after the completion of the study.

When we present or publish the results of this study, we will not use your name or other information that may identify you.

X. Contact Information:

Contact Jessica-Kim Danh at jdanh1@gsu.edu or by phone/text at 813-407-8415

- If you have questions about the study or your part in it
- If you have questions, concerns, or complaints about the study

The IRB at Georgia State University reviews all research that involves human participants. You can contact the IRB if you would like to speak to someone who is not involved directly with the study. You can contact the IRB for questions, concerns, problems, information, input, or questions about your rights as a research participant. Contact the IRB at 404-413-3500 or irb@gsu.edu.

XI. Consent:

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

If you are willing to volunteer for this research, please sign below.

Printed Name of Participant

Signature of Participant Date

Principal Investigator or Researcher Obtaining Consent Date

Appendix 2

Department of Nutrition

Georgia State University

HEALTH AND FITNESS HISTORY QUESTIONNAIRE

The following questions are designed to obtain your lifestyle and medical history. Please answer all questions and provide as much information as you possibly can. This questionnaire, as well as any other medical information you provide will be kept confidential and will not be shared with any unauthorized person or organization unless you specifically request us to do so.

Skeletal and Joint Health

Q 1.1 Do you have a history of skeletal and/or joint disorders? Please choose the most appropriate response.

- No, I have not had any skeletal and/or joint disorders. Skip to *Personal Health History*.
- Yes, but it's uncontrolled (i.e. you do not have an active treatment for it)
- Yes, and I am/have been treating it.

If you answered yes, please answer the following question:

How has this condition affected your activity? [Text Field]

Which joint(s) is afflicted? Please indicate left, right, or both. [Text Field]

Please describe how frequent pains occur: [Text Field]

Please describe how severe the pain is from a scale of 1-10 with 10 being the most severe. You are free to include more detail. [Text Field]

If you answered "yes, and I am/have been treating it," please indicate which treatments you have undergone. Select all that apply.

- Medications
- Exercise Program
- Modified Diet
- Surgery

Q 1.2 Do you have a family history of skeletal/joint disorders?

- Yes
- No

Personal Health History

Q 2.1 Have you ever been hospitalized or had surgery?

- Yes
- No

If you answered yes, please provide details below.

Reason for Hospitalization or Operation	Duration	Age When Hospitalized

Q 2.2 Are you currently seeing a doctor or other health care provider for any reason outside of normal check-ups?

- Yes
- No

Q 2.3 For female participants: When was your last menstrual cycle? [MM/DD/YYYY]

Q 2.4 Have you ever been diagnosed as having any of the following? Circle yes to next to any that apply.

High Blood Pressure	Yes
High Cholesterol/Triglycerides	Yes
Type 1 Diabetes	Yes
Type 2 Diabetes	Yes
Hypoglycemia (Low Blood Sugar)	Yes
Liver or Renal Disease/Complications	Yes

Q2.5 Are you currently taking any medication?

- Yes
- No

If you answered yes, please list your medications. [Text Field]

Q2.6 Do you have any neurological disorders including fainting, dizziness, headaches or seizures?

- Yes
- No

Q2.7 Do you have any orthopedic or other health problems that may affect your ability to perform exercise?

- Yes
- No

If yes, please explain. [Text Field]

Q2.8 Are you allergic, sensitive or intolerant of any foods or medications?

- Yes
- No

If yes, please explain. [Text Field]

Q2.9 Have you made any changes to your diet in the last six months?

- Yes
- No

If yes, please explain. [Text Field]

Q2.10 Do you smoke or use smokeless tobacco (e.g. vape)?

- Yes
- No

If yes, how many cigarettes per day? [Text Field]

Q2.11 Have you had a physical exam in the past 2 years?

- Yes
- No

Q2.12 Please describe your assessment of your overall health. [Text Field]

Appendix 3

Three-Day Food Record Packet

Georgia State University

Three-Day Food Record

Department of Nutrition

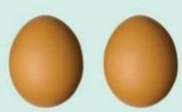
Completing Your 3-Day Food Record

Follow the guidelines below to complete your food record. If you have any questions or need assistance, please contact Jessica-Kim Danh at jdanh1@gsu.edu or call/text at 813-407-8415.

- **Include two weekdays (Monday-Friday) and a weekend day (Saturday or Sunday) for a total of three days.** They do not have to be consecutive.
- When recording, select days that are **typical** of your everyday eating habits. Holidays and special events may not be representative of what you usually consume. If you do happen to have a non-typical day, please make a note of it in your journal or in the special notes field in the Google Form.
- Record **immediately** after items are consumed (both food and drink) to reduce recall errors later on.
- If you eat/drink right before or right after training or practice, please include a note about it in the note section of your diary.
- **RECORD EVERYTHING**. This includes sauces/condiments, cream in your coffee, etc.
- Estimate portion sizes to the best of your ability. For help, use the serving size guide on the next page.
- **Please be honest.** The purpose of these records is to get the best representation of your usual eating habits so that the research team can provide data that will better support you and your performance.
- Don't stress! If you need assistance, just reach out to the research team.

Special notes about this food record:

- Start a new page for a new day and please circle if it is a weekday or weekend.
- Please be sure to indicate if the food/drink was consumed before, during, or after a workout/training session.

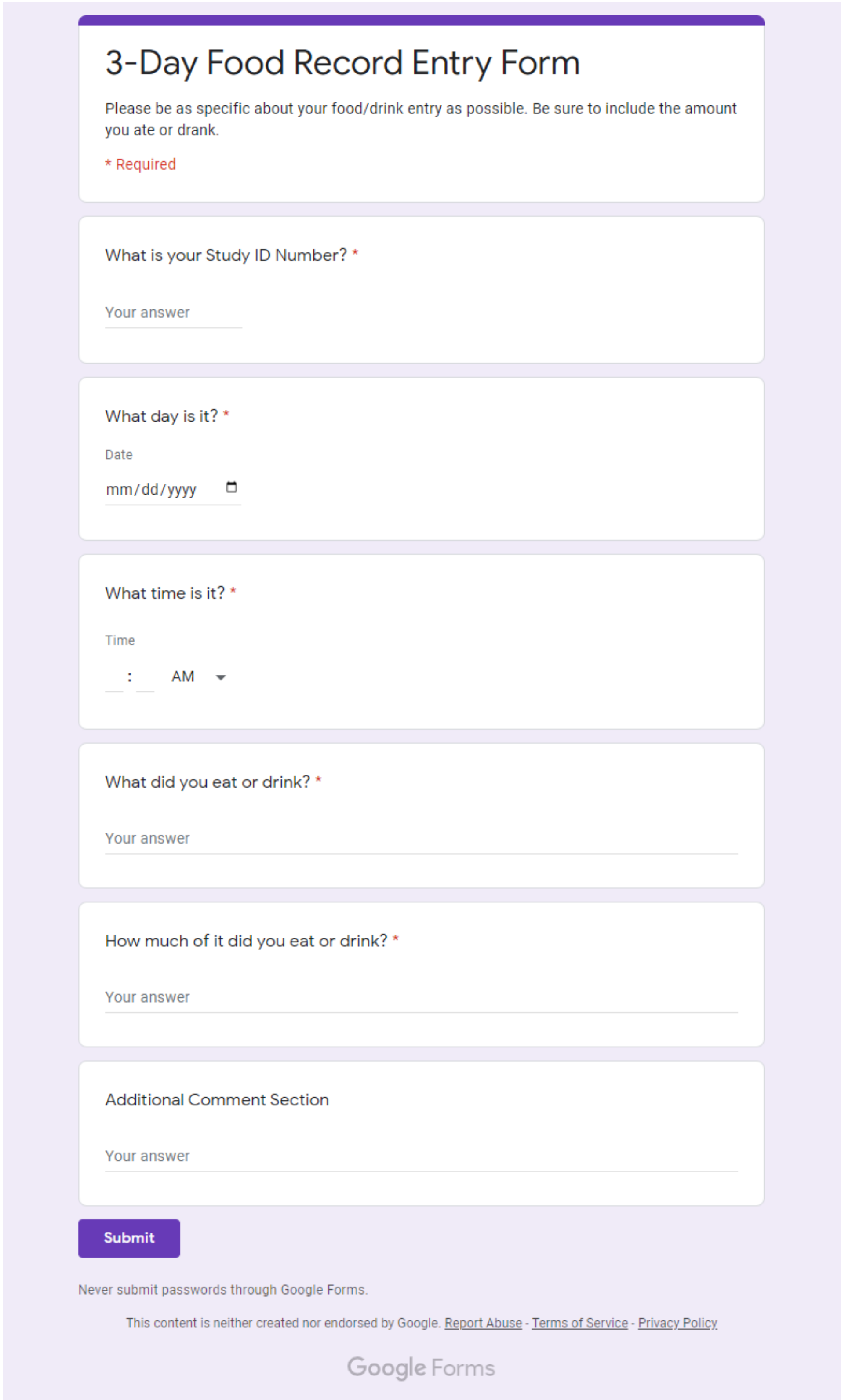
Object	Hand Symbol	Equivalent	Foods
		**Fist** 1 Cup (baseball)	Rice, Pasta Fruit Veggies
		**Palm** 1/2 cup (tennis ball)	Medium Fruit, Ice Cream
		**Palm** 3 ounces (deck of cards)	Meat Fish Poultry
		**Handful** 1 ounce (1 large egg)	Nuts Raisins
		**2 Handfuls** 1 ounce (2 large eggs)	Chips Popcorn Pretzels
		**Thumb** 1 ounce (ping pong ball)	Peanut Butter Hard Cheese
		**Thumb Tip** 1 teaspoon (marble)	Cooking Oil Mayonnaise, Butter Sugar

STUDY ID # ________________

Circle One: Weekday or Weekend

Date & Time Indicate if it was before, during, or after exercise when applicable	**Description of Food/Drink**	**Amount**

Three-Day Food Record Entry



3-Day Food Record Entry Form

Please be as specific about your food/drink entry as possible. Be sure to include the amount you ate or drank.

* Required

What is your Study ID Number? *

Your answer

What day is it? *

Date

mm/dd/yyyy

What time is it? *

Time

: AM

What did you eat or drink? *

Your answer

How much of it did you eat or drink? *

Your answer

Additional Comment Section

Your answer

Submit

Never submit passwords through Google Forms.

This content is neither created nor endorsed by Google. Report Abuse - Terms of Service - Privacy Policy

Google Forms

Appendix 4

NUTRITION KNOWLEDGE QUESTIONNAIRE

Weight Management

Q1.1 Which nutrient do you think has the most energy (calories) per 3.5 oz (100 grams)?

- ❍ Carbohydrate
- ❍ Protein
- ❍ Fat
- ❍ Not Sure

Q1.2 The following are statements about weight management. Please select agree, disagree or not sure:

	Agree	Disagree	Not Sure
1. In endurance sports, having the lowest weight possible benefits performance in the long term (D)	❍	❍	❍
2. Increasing protein in the diet is the main dietary change needed when only muscle gain is desired (D)	❍	❍	❍
3. Protein eaten more than bodily needs can lead to fat gain (A)	❍	❍	❍

Q1.3 The following are some strategies one might try to lose weight (or reduce body fat). Please indicate if you think these are effective, not effective or you are not sure.

	Effective	Not Effective	Not Sure
1. Swap carbohydrate/energy dense foods for low-energy foods such as vegetables (E)	❍	❍	❍
2. Swap butter for canola spread (polyunsaturated margarine) (NE)	❍	❍	❍
3. Exchange yogurts, muesli/granola bars and fruit snacks for protein bars and shakes (NE)	❍	❍	❍
4. Choose lower glycemic index (GI) carbohydrates to help regulate appetite (E)	❍	❍	❍

Q1.4 When weight loss is desired, generally athletes should:

- ❍ Decrease carbohydrate intake to less than 1.7 ounces (50 grams) per day
- ❍ Decrease fat intake to less than 0.7 ounces (20 grams) per day
- ❍ Decrease calories below energy needs
- ❍ Not Sure

Q1.5 To ensure they meet their energy (calorie) requirements, all athletes should:

- ❍ Plan their diet according to their age, gender, body size, sport and training program
- ❍ Eat to appetite following their natural hunger and fullness signals
- ❍ Eat a minimum of 2000 calories per day
- ❍ Choose foods that are high in carbohydrate
- ❍ Not Sure

Q1.6 Which do you think is the best lunch option for an athlete trying to gain weight (muscle)? Assume they are training in the morning and have already had breakfast and a mid-morning snack.

- ❍ A 'mass gainer' protein shake and 3 - 4 scrambled eggs
- ❍ Pasta with lean beef and vegetable sauce, plus a dessert of fruit, yoghurt and nuts
- ❍ A large piece of grilled chicken with a side salad (lettuce, cucumber, tomato)
- ❍ A large steak and fried eggs
- ❍ Not Sure

Q1.7 Which do you think is the best lunch option for an athlete trying to lose weight? Assume they are eating an appropriate breakfast and dinner.

- ❍ A side salad with no dressing (lettuce, cucumber, tomato)
- ❍ A pure whey protein isolate (WPI) shake made on water
- ❍ A mixed meal that includes a small-moderate serving of meat and carbohydrate (e.g. small bowl pasta with lean mincemeat and vegetable sauce) plus a large side salad
- ❍ Not Sure

Macronutrients

Q2.1 How much carbohydrate do you think is recommended for an athlete undertaking a moderate to high-intensity endurance training program for one to three hours per day?

- ❍ 1 - 3 g carbohydrate per kg body weight per day
- ❍ 5-7 g per kg, increasing up to 10 g per kg with intense training/competition loads 15 - 25% of total daily calorie intake
- ❍ 75 - 85% of total daily calorie intake
- ❍ Not Sure

Q2.2 Which of these foods would provide enough carbohydrate for a recovery from intense exercise? Assume the athlete weighs about 154 lbs (70kg) and has an important training session again tomorrow.

	Enough	Not enough	Not Sure
1. 1 Medium Banana (NE)	❍	❍	❍
2. 1 cup cooked Quinoa and 1 tin tuna (NE)	❍	❍	❍
3. 1 cup plain yoghurt (NE)	❍	❍	❍
4. 1 Cup Baked Beans on two slices of bread (E)	❍	❍	❍

Q2.3 Which of the following foods do you think contains the most carbohydrate?

- ❍ 1 cup (168 g/5.6 oz) boiled rice
- ❍ 2 slices of white sandwich loaf bread
- ❍ 1 medium (150 g/ 5 oz) boiled potato
- ❍ 1 medium (150 g/5 oz) ripe banana
- ❍ Not Sure

Q2.4 The following statements are about fat. Please select agree, disagree or not sure.

	Agree	Disagree	Not Sure
1. Fat is required by the body to make cell membranes and molecules involved in immune function (A)	❍	❍	❍
2. For athletes, no more than 20g of fat should be eaten per day (D)	❍	❍	❍
3. When exercise intensity increases, the relative amount (%) of fat that is burnt to supply the body with fuel increases (D)	❍	❍	❍

4. When exercising at low intensities, fat provides almost all the substrate needed to cover energy costs (A)	❍	❍	❍

Q2.5 Do you think these foods are high or low in fat?

	High	Low	Not Sure
1. Cheddar cheese (H)	❍	❍	❍
2. Margarine (H)	❍	❍	❍
3. Mixed nuts (H)	❍	❍	❍
4. Honey (L)	❍	❍	❍

Q2.6 The following statements are about protein. Please select agree, disagree or not sure.

	Agree	Disagree	Not Sure
1. Protein is the main source of energy used by muscles during exercise (D)	❍	❍	❍
2. Vegetarian athletes can meet their protein requirements without the use of protein supplements (A)	❍	❍	❍
3. A well trained athlete needs more protein than a young athlete who is just beginning training (D)	❍	❍	❍
4 The body has a limited ability to use protein for muscle protein synthesis (A)	❍	❍	❍
5. A balanced diet with adequate kilojoules/calories (energy) should meet all protein needs (A)	❍	❍	❍

Q2.7 Which of the following foods do you think contains the most protein?

- ❍ 2 eggs
- ❍ 3 oz (100g) raw skinless chicken breast
- ❍ 1 oz (30g) almonds
- ❍ Not Sure

Q2.8 The protein needs of a 220lb (100kg) well trained resistance athlete are closest to:

- ❍ 100g (1.0 g/kg)
- ❍ 150 g (1.5 g/kg)
- ❍ 500g (5.0 g/kg)
- ❍ Not sure

Q2.9 Which of these foods have enough protein to promote muscle growth after a bout of resistance exercise?

	Enough	Not enough	Not Sure
1. 3 ounces (100g) Chicken Breast (E)	❍	❍	❍
2. 1 ounce (30g) Yellow Cheese (NE)	❍	❍	❍
3. 1 Cup Baked Beans (NE)	❍	❍	❍
4. 1/2 Cup Cooked Quinoa (NE)	❍	❍	❍

Q2.10 Do you think these foods contain all the essential amino acids needed by the body?

	Yes	No	Not Sure
1.Beef Steak (Y)	❍	❍	❍
2. Eggs (Y)	❍	❍	❍
3. Lentils (N)	❍	❍	❍
4. Cow's Milk (Y)	❍	❍	❍

Q2.11 The amount of protein in skim milk compared to full cream milk is:

❍ Much less
❍ About the same
❍ Much more
❍ Not Sure

Micronutrients

Q3.1 The following are statements about the role of different micronutrients. Please select agree, disagree or not sure.

	Agree	Disagree	Not Sure
1. Calcium is the largest structural component of bone crystals (A)	❍	❍	❍
2. Vitamin C acts as an anti-oxidant in the body (A)	❍	❍	❍
3.Thiamine (Vitamin B1) is required for efficient delivery of oxygen to muscles (D)	❍	❍	❍
4. The main role of Iron is the conversion of food into usable energy (D)	❍	❍	❍
5. Vitamin D enhances calcium absorption (A)			

Q3.2 The following statements are about the food sources of different micronutrients. Please select agree, disagree or not sure.

	Agree	Disagree	Not Sure
1. Meat, Chicken and Fish are good sources of zinc (A)	❍	❍	❍
2. Wholegrain foods are good sources of vitamin C (D)	❍	❍	❍
3. Fruit and Vegetables good sources of calcium (D)	❍	❍	❍
4. Fatty fish is a good source of Vitamin D (A)	❍	❍	❍

Q3.3 The following statements are about athlete's vitamin and mineral requirements. Please select agree, disagree or not sure.

	Agree	Disagree	Not Sure
1. Women who are menstruating have higher iron needs than men (A)	❍	❍	❍
2. The optimal calcium intake for athletes aged 15 to 24 years is 500 mg (D)	❍	❍	❍
3. A physically fit person eating a nutritionally adequate diet can improve their performance by eating more vitamins and minerals from food (D)	❍	❍	❍
4. Vitamins provide the body with energy (calories) (D)	❍	❍	❍

Sports Nutrition

Q4.1 Athletes should drink water during activity in order to:

- Maintain plasma (blood) volume
- Prevent dry mouth
- Maintain sweat volume
- All of the above
- Not Sure

Q4.2 Regarding fluid intake during physical activity, current recommendations encourage athletes to:

- Drink 50 - 100 ml (1.7 - 3.3 fluid oz) every 15 - 20 minutes
- Suck on ice cubes rather than drinking during practice
- For demanding session, drink sports drinks (e.g. Powerade) rather than water when exercising
- Drink to a plan, based on body weight changes during training sessions performed in a similar climate
- Not Sure

Q4.3 How much sodium (salt) should fluid consumed for hydration purposes (during exercise) contain?

- At least 11 - 25 mmol/L (~ 250 - 575 mg/L)
- At least 4 - 8 mmol/L (~ 90 - 185 mg/L)
- None
- Not Sure

Q4.4 Before competition, athletes should aim to consume foods that are high in:

- Fluids, fat and carbohydrate
- Fluids, fiber and carbohydrate
- Fluids and carbohydrate
- Not Sure

Q4.5 The following statements are about carbohydrate consumption during exercise. Please select agree, disagree or not sure.

	Agree	Disagree	Not Sure
1. Consuming carbohydrate during exercise can REDUCE ability to develop strength and muscle gains(D)	❍	❍	❍
2. In events lasting 60 - 90 minutes, 30- 60 g (1.0 - 2.0 ounces) of carbohydrates should be consumed per hour (A)	❍	❍	❍
3. Consuming carbohydrate during exercise will assist in maintaining blood glucose levels (A)	❍	❍	❍

Q4.6 Stomach discomfort is sometimes reported by athletes who eat during exercise. Which of the following is NOT a good strategy to avoid discomfort?

- ❍ Having energy gels instead of water or sports drinks
- ❍ Consuming small volumes at regular intervals
- ❍ Choosing sports drinks/foods with a mixture of types of carbohydrate (e.g. fructose and sucrose)
- ❍ Not Sure

Q4.7 During a competition, athletes should aim to consume foods that are high in:

- ❍ Fluids, fiber and fat
- ❍ Fluids and protein
- ❍ Fluids and carbohydrate
- ❍ Not Sure

Q4.8 Which of the following best meets the recommendations for a snack consumed during high-intensity exercise lasting around 90 minutes?

- ❍ A protein shake
- ❍ A ripe banana
- ❍ 2 Boiled eggs
- ❍ A handful of nuts
- ❍ Not Sure

Q4.9 After a competition, athletes should aim to consume foods that are high in which macronutrient/s?

- ❍ Protein, carbohydrate and fat
- ❍ Only protein
- ❍ Only carbohydrate
- ❍ Carbohydrate and protein
- ❍ Not Sure

Q4.10 How much protein do you think experts recommend athletes should have after completing a resistance exercise session?

- ❍ 0.3g/kg body weight (~ 15 - 25 g [0.53 - 0.88 oz] for most athletes)
- ❍ 1.0 g/kg body weight (~ 50 - 100 g [(1.9 - 2.3 oz)] for most athletes)
- ❍ 1.5g/kg body weight (~ 150 – 130 g [5.3 – 10.6 oz] for most athletes)
- ❍ Not Sure

Supplementation

Q5.1 The following are statements about athletes' needs for particular micronutrient supplements. Please select agree, disagree or not sure.

	Agree	Disagree	Not Sure
1. Vitamin C should be routinely supplemented by athletes (D)	❍	❍	❍
2. B Vitamins should be taken when feeling low in energy (D)	❍	❍	❍
3. Salt tablets should be used by athletes that get a cramp during exercise (D)	❍	❍	❍
4. Iron tablets should be taken when a player feels extremely tired and is pale (D)	❍	❍	❍

Q5.2 The purity and safety of all supplements are tested before sale.

- ❍ Agree
- ❍ Disagree
- ❍ Not Sure

Q5.3 Supplement labels may contain false or misleading information.

- ❍ Agree
- ❍ Disagree
- ❍ Not Sure

Q5.4 The following statements are about the reported benefits of performance-enhancing supplements. Please select agree, disagree or not sure.

	Agree	Disagree	Not Sure
1. Creatine reduces perceived effort of exercise by acting on the central nervous system (D)	❍	❍	❍
2. Caffeine improves efficiency of muscles at a given rate of oxygen delivery (D)	❍	❍	❍
3. Beetroot Juice (nitrates) decrease muscle breakdown and reduce muscle soreness (D)	❍	❍	❍
4. Beta-Alanine produces carnosine, a protein that can buffer ("soak up") acid by-products produced during high-intensity activity(A)	❍	❍	❍

Q5.5 In relation to their intended purpose, which of the following supplements do you think has NOT been supported by a strong body of scientific evidence?

- ❍ Caffeine
- ❍ Ferulic acid
- ❍ Bicarbonate
- ❍ Leucine
- ❍ Not Sure

Q5.6 Which of the following supplements do you think is banned by the WORLD ANTI-DOPING AGENCY (WADA)?

- ❍ Caffeine
- ❍ Bicarbonate
- ❍ Carnitine
- ❍ Testosterone
- ❍ Not Sure

Alcohol

Q6.1 How many grams/ fluid ounces of ethanol (pure alcohol) does a standard drink generally contain?

- ❍ 1 - 2 / 0.03 - 0.06 fl. oz
- ❍ 8 - 14 g/ 0.3 - 0.6 fl. oz
- ❍ 30 - 50 g /1.2 - 2.0 fl. oz
- ❍ Not Sure

Q6.2 Which of the following do you think is an example of a "Standard Drink"?

- 30 - 45 ml/1 - 1.5 fl. oz of pure spirits
- One quarter of a bottle (175 ml/ 6 fl. oz) of red wine
- A pint (425 ml/ 14 fl. oz) of full-strength beer
- Not Sure

Q6.3 When consumed as part of the diet, pure alcohol (ethanol) contains calories and, therefore, can lead to weight gain.

- Agree
- Disagree
- Not Sure

Q6.4 For individuals who choose to drink alcohol, to reduce the risk of alcohol-related harm over a lifetime, no more than _____ standard drinks should be consumed per day:

- Two
- Three
- Four
- Not Sure

Q6.5 The following statements are in relation to alcohol consumption. Please select agree, disagree or not sure.

	Agree	Disagree	Not Sure
1. If someone does not drink at all during the week, it is okay for them to have five or more drinks on a Friday or Saturday night (D)	❍	❍	❍
2. Drinking large amounts of alcohol can reduce recovery from injury (A)	❍	❍	❍
3. Alcohol has been shown to increase urinary losses during post-exercise recovery (A)	❍	❍	❍

Q6.6 "Binge drinking" (also referred to as heavy episodic drinking) is generally defined as:

- Having two or more standard alcoholic drinks on the same occasion
- Having four to five or more standard alcoholic drinks on the same occasion
- Having seven to eight or more standard alcoholic drinks on the same occasion
- Not Sure

Nutrition Resources

Q7.1 Where do you go to get your sports nutrition related information? Select all that apply.

- ❍ Coach(es)
- ❍ Athletic Trainer
- ❍ Strength and Conditioning Coach
- ❍ Registered Dietitian Nutritionist
- ❍ Nutritionist
- ❍ Nurse
- ❍ Physician
- ❍ Physical Therapist
- ❍ Internet Search
- ❍ Social Media (Facebook, Reddit, Instagram, etc.)
- ❍ Teammates
- ❍ Friends
- ❍ Family
- ❍ Scientific Articles
- ❍ Books and Magazines
- ❍ Other

Q7.2 Of the options you chose in the previous question, which are your top three resources? Make your first selection the resource you use most.

Q7.3 Do you feel you have adequate sports nutrition knowledge?

- ❍ Yes, and I apply it as part of my training regimen.
- ❍ Yes, but I don't really apply it.
- ❍ No, but I would like to learn more.
- ❍ No, but that's what trainers and coaches are for.

Demographic Information & Other

Q8.1 Which sport do you play? [Drop-down selection of GSU sports teams]

Q8.2 How long have you been playing competitive in the sport you selected above? [Text Field] year(s)

Q.8.3 Which year are you in university?

- ❍ Freshman
- ❍ Sophomore
- ❍ Junior
- ❍ Senior

Q8.4 Gender

- ❍ Female
- ❍ Male
- ❍ Prefer not to answer

Q8.5 Age

- ❍ 18-22 Years
- ❍ 23-26 Years
- ❍ 27-30 Years
- ❍ 31 Years or Older
- ❍ Prefer not to answer

Q.8.6 Ethnicity

- ❍ Caucasian
- ❍ African American
- ❍ Asian
- ❍ Hispanic
- ❍ Other
- ❍ Prefer not to answer

Q8.7 How would you describe your diet?

- ❍ Vegetarian
- ❍ Lacto-Vegetarian
- ❍ Pesco-Vegetarians
- ❍ Lacto-ovo-vegetarian
- ❍ Vegan
- ❍ Gluten-Free
- ❍ Ketogenic
- ❍ Low Carb
- ❍ Paleo

- I don’t have dietary restrictions
- Other [Text Field]

Q8.8 Are you currently trying to…

- Gain Weight
- Lose Weight
- Maintain Weight
- I’m not currently trying any of the above.

Q8.9 Have you participated in any of the following? Select all that apply.

- Nutrition Courses
- Nutrition Workshops/Seminars
- Health Workshops/Seminars
- Health and Nutrition Related Conferences
- Other

Appendix 5

Body Composition

Study ID # ________________________________

Date _____________________

Body Composition Measurements

Height	
Weight	
Body Fat %	
RMR	

Appendix 6

Physical Activity Form

Study ID # ______________________________

Date ____________________

Physical Activity Questions

1. How many training/practice sessions did you attend in the past week?

2. Of those sessions, how many were:
   a. Intense sessions (a lot of sweating and heavy breathing) __________
   b. Moderate sessions (sweating and heavy breathing but quick to recover) __________
   c. Easy sessions (light sweating) __________

3. How long was practice/training on average?

4. What kind of training was involved? E.g. Sprints, long-distance runs, resistance, skill-work.

5. Did you work out outside of training/practice sessions this past week? If no, skip the last two questions.

6. How many times did you work out outside of training/practice?

7. Did any of your workouts fall on the same day as training/practice? If yes, how many?