Nutrition Knowledge and Dietary Quality in Female Collegiate Cross Country Runners

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Abstract

Introduction: High dietary quality is important for athletic populations because it may reduce nutritional deficiencies. Female cross country runners are often at risk for deficiencies in key nutrients, such as iron and calcium. Athletes' nutrition knowledge has been shown to influence their selection of higher quality foods. However, an assessment of nutrition knowledge and dietary practices in female collegiate cross country runners remains unknown. **Purpose**: To explore and assess sports nutrition knowledge and dietary behavior in collegiate female runners. **Methods**: Female cross country athletes (n=12) from Florida Southern College completed a 30-item sports nutrition knowledge questionnaire, testing their knowledge of the following: energy intake, macronutrients, and micronutrients. Participants then recorded their food intake for 3 non-consecutive days (within a 1-week time frame). Results were entered into an online dietary tracker, which sorted daily food intake into different nutrient categories. Trends observed within athletes' nutrition knowledge and dietary habits were analyzed. **Results**: Results indicate athletes scored at an average (75%) level in sports nutrition competencies, with better understanding of macronutrients versus micronutrients. The food log analysis indicated the majority of runners' diets were deficient in several key nutrients, especially calories, carbohydrates, and Vitamin D. **Conclusions**: Athletes minimally achieved the standard for adequate nutrition. Nutrient intake appeared low for most nutrients, regardless of knowledge. These nutrient deficits may impair performance and exacerbate injury risk. Future studies may explore educational interventions that facilitate better dietary practices in athletes.

Literature Review

Introduction

Often, the 'little things' athletes do outside of their training are just as important as the training itself; nutrition is one such thing. Nutrition is a vital component of health and wellness. According to the World Health Organization, nutrition aids in increasing longevity, improving immune functions, elevating the safety of pregnancy and childbirth, and lowering the risk of non-communicable diseases such as diabetes (22). For athletes, sports nutrition has more relevance. Sports nutrition is a field specifically devoted to understanding how macronutrients, micronutrients, fluids, supplements, and nutrient timing influence different components of athletic performance (13). The value of sports nutrition cannot be overstated in the long distance runner. The high-intensity, long duration activity of running can deplete fuel reserves, lower energy availability, and lead to fatigue, subsequently lowering performance. Proper nutrition can aid in restoring energy levels back to their optimal levels, and has a beneficial impact in recovery, injury prevention, growth, development, and performance (6).

Improving nutrition knowledge is one method of enhancing dietary habits. With their efforts focused on training, academic achievement, and other obligations such as work or social functions, student athletes may have little time or patience to focus on enriching their dietary quality. Indeed, studies have revealed that college athletes have poor or deficient diet quality (10,15). Therefore, the purpose of this review of literature is to explore the influence of sports nutrition knowledge on dietary habits in collegiate runners.

Sports Nutrition

Sports nutrition is an "invisible training" that has a large influence on athletes' peak performance. Amount, type, and timing of food intake is integral to supporting health, performance, and recovery in sport (18). Sports nutrition encompasseses a broad range of topics, including macronutrients, micronutrients, supplementation, fluids, recovery meals, alcohol, energy balance, body composition, nutrient requirements for sport energy pathways, nutrient intake in special populations, and nutrient timing before, during and after competition (13,18). Because of the wide array of factors involved in sports nutrition, someone's dietary habits cannot be judged by the simple labels "healthy" or "unhealthy". Furthermore, one's dietary habits, goals, and requirements are not static; they fluctuate depending on factors such as physical activity habits, sleep habits, food availability, and environment. Sports nutrition is a complex topic that involves different methods of application for each client. Yet simultaneously, the well-established tenets of sport nutrition science form the basis of nutritional knowledge.

Nutritional Needs of Distance Runners

As endurance athletes, cross country runners have a specific set of nutritional needs that vary with respect to their sport. Key characteristics of running are the high volume, high impact nature of the sport underscored by the high number of miles runners track every week, and the ground reaction forces placed on tendons, ligaments, and bones in the legs. Furthermore, cross country runners rely heavily on prolonged aerobic training, which strengthens muscles, tendons, ligaments and bones, improves efficiency of movement, enhances the body's ability to use fat as a substrate, and increases cardiac output, stroke volume, and blood volume, thereby bettering cardiovascular efficiency (20). Although endurance training is certainly beneficial, it is not a sustainable way of living without appropriate increases in energy intake, macronutrient intake, and key vitamins that relate to nutritional needs.

Due to their high volume of training, distance runners burn an abundance of calories in their daily training, and therefore have much greater energy needs than other types of athletes. Low energy intake and availability is a common occurrence in this sport, especially in female athletes, due to the oversimplified belief that lighter body weights lead to better performances (4). As such, distance runners may be prone to restrict caloric intake; one probable consequence of this is low energy availability. Indeed, one study concluded that 53% of Division 1 female endurance runners were calculated to have a low energy availability (below 30 kcal·kg-1·FFM·d-1) and 40% reported current clinical menstrual dysfunction (3). Focus on attaining leaner, lighter bodies can contribute to eating disorders such as anorexia nervosa or bulimia or, at the very least, nutritional deficiencies. Moreover, caloric restriction can lead to relative energy deficiency syndrome, which is a combination of poor eating patterns, low bone density, and amenorrhea (in females). Ultimately, this chronic energy deficiency can lead to long term negative health implications that extend far beyond hindered performance and lead to stress injuries, permanently altered bone health, hormonal disruptions, and kidney failure (4).

The current sports nutrition recommendations for carbohydrate intake are 5-7 g/kg/day for moderate exercise (1 hr/day), 6-10 g/kg/day for high intensity exercise (1-3hrs/day) and 8-12 g/kg/day for very high activity levels (4-5hrs/day) as often seen in ultraendurance athletes. Carbohydrate is stored in the muscles and liver as glycogen, and its stores are important to replenish, because they deplete relatively quickly, which can lead to "hitting the wall" during a time consuming endurance activity such as marathon running. It can produce more ATP per volume of oxygen than fat and, as such, contains a high amount of energy. To avoid fatigue induced by limited glucose supplies during aerobic activity, it is important that carbohydrates be consumed before, during, and after activity. It is recommended that 1-4 g/kg/day be consumed 1-4 hours prior to activity to load the body with glycogen; 30-60 g/kg/day be consumed during activity less than 2.5 hours to fuel the body during activity and avoid total depletion; and 1.0-1.2 g/kg/day be consumed 3-5 hours after activity, in combination with protein (14).

Endurance athletes should consume the lower end of the range of 1.2-2.0 g/kg/day of protein dispersed into 0.3 g bouts every 3-5 hours throughout the day (18). Muscle protein synthesis is upregulated 24 hours post-exercise due to increased oral sensitivity. Due to increased absorption, post-exercise protein consumption is optimal and recommended for maintaining muscle mass. A danger for endurance athletes is the potential for their muscles to enter a catabolic state and breakdown after prolonged endurance activity if they do not replenish their bodies with a sufficient amount of protein (14).

As endurance athletes become better adapted to their sport, they increase their metabolic efficiency by maintaining the same speed as a lower intensity (21). At this lower intensity, fat can be used as a fuel source. Furthermore, fat contains a very high level of kcals and is beneficial for an athlete after 1-1.5 hours of running in order to help power an endurance athlete through the remainder of their activity session when glycogen stores are low. It is recommended that endurance athletes consume 20-35% of calories from fat (18). Despite their recent increase in popularity, high fat, low carbohydrate diets do not elevate performance; rather, they often restrict an athlete's ability to race at higher intensities (14).

Iron, vitamin D, and calcium are three extremely important micronutrients for distance runners. The biological role of iron is that it helps store and deliver oxygen to the tissues with hemoglobin and myoglobin. This is very important in endurance running, an aerobic activity where oxygen transport is essential (4). All runners are more at risk of having low energy levels due to gastrointestinal bleeding and inflammation, both products of distance running. Female runners are further at risk for low iron levels because they are more likely to engage in energy restriction and vegetarianism than males, and lose iron monthly during menstruation. Therefore, special attention must be paid to iron to ensure distance runners are obtaining adequate amounts of the nutrient. Calcium and vitamin D play an important role in bone health as well as immune and muscular functions. It is necessary for endurance runners to maintain healthy bone structure to support their running; low bone density can lead to stress injuries and poor performance. Vitamin D is found in very few foods, but is often absorbed from sun exposure. However, places or seasons which tend to lack sunlight, indoor sports, or usage of sunscreen can lead to low levels of Vitamin D absorption. Thus, supplementation may be needed. Calcium can be lost in sweat and urine; thus long distance runners, who often have very high levels of sweat during exercise, have a greater need for calcium than other athletes (4).

Nutrition Knowledge

Nutrition knowledge, broadly defined, is the knowledge of concepts about health and wellness, disease prevention, and human performance as it relates to nutrition. Nutrition knowledge is one of the few modifiable determinants of dietary behavior (13). By influencing dietary quality, nutrition knowledge also has the potential to also improve overall performance, reduce injury risk, increase bone strength and support recovery in athletes. Despite its potential to improve diet quality, current evidence indicates that inadequate levels of sports nutrition knowledge are ubiquitous among college athletes (12,15–17). Multiple studies have shown that collegiate and elite athletes tend to score in the range of 50-65% on nutrition questionnaires

(12,15–17). Additionally, evidence backs the idea that college athletes' levels of knowledge are significantly lower than coaches, athletic trainers (ATs), and strength and conditioning specialists (SCSs) (12). While this may be expected given the differences in education, it seems counterintuitive that the population with the most potential to benefit from sports nutrition knowledge (namely college athletes) have the least amount of this knowledge.

Several studies illustrate the lack of sports nutrition knowledge in athletes. One such study assessed sports nutrition knowledge in ultraendurance athletes and compared their score to that of the general population (1). The questionnaire, called the Ultra-Q, included four sections on nutrients, fluid, recovery, and supplements. The outcomes were that the mean score for ultraendurance athletes was 68.3% ± 9.5; these scores were significantly higher than those of the general population, but significantly lower than sports and exercise nutrition registrar. This score is below the 75% threshold score set by, and is therefore slightly "below par". These inadequate levels of knowledge are juxtaposed by the great need for optimal dietary habits that maintain health and support performance in a high volume, high intensity, calorically demanding sport. The lowest scoring section was on supplementation and fluids, which supports previous research that exercise-induced hyponatremia affects up to 51% of ultraendurance athletes. The poor scores observed may be because over 70% of athletes get their nutrition information from magazines and other athletes, while fewer than 10% consult a nutrition professional or have a nutrition certification (1). Because this study assesses a group of long-distance athletes, including ultrarunners, results may apply to college runners.

In another study by Tores-McGehee and others, researchers surveyed groups of college athletes, ATs, SCSs, and coaches to assess sports nutrition knowledge and confidence levels about this knowledge (12). The questionnaire was composed of 20 multiple choice questions about micronutrients and macronutrients, weight managements and eating disorders, supplements and performance, and hydration. It was found that athletes scored the lowest on the survey, averaging 54.9%. The questions for which athletes performed most poorly were related to weight management and eating disorders; likewise, they performed best on the supplement questions. 91% of athletes surveyed had inadequate sports nutrition knowledge, as defined by a score lower than 75% on the questionnaire. ATs and SCSs had the highest mean scores (77.8% and 81.6%, respectively) and were most confident in their answers (12). The difference in scores between ATs/ SCSs and college athletes is likely to be explained by their levels of education. Thus, this study highlights not only the inadequacy in college athletes' sports nutrition scores, but also the role of education in improving baseline levels of sports nutrition knowledge.

In addition, a cross-sectional study by Weeden and colleagues used a 65-Nutrition Knowledge and Behavior questionnaire to compare nutrition knowledge between different sports in 174 Division 1 collegiate athletes (16). The questionnaire was designed with the help of a nutrition textbook along with dietitians and health specialists; it contained questions on macronutrients, micronutrients, hydration, dietary supplements, and weight management. The mean nutrition knowledge was 56.4% ± 13.4 with no significant differences in knowledge between gender or sport. Participants scored highest on topics of protein and electrolytes, and, consistent with findings by Torrhes-McGehee and colleagues, scored lowest on topics of weight loss (12,16). The results reaffirm that college athletes have low levels of nutrition knowledge. Factors that correlated with better questionnaire results were reliance on dietitians as one's primary source of nutrition information, previous enrollment in a college level nutrition course, and participation in individual sports (16). Thus, college cross country athletes, who partake in an individual, may have better nutrition knowledge than other types of collegiate athletes.

A 2019 study by Lohman, Carr, and Condo assessed sports nutrition knowledge in 66 male Australian football players (7). Researchers employed an 88-item sports nutrition knowledge questionnaire (SNKQ) composed of 46 questions on general nutrition concepts, 15 questions on weight control, 11 questions on supplements, 9 questions on fluids, and 7 questions about recovery. Overall scores demonstrated no significant differences between elite and sub-elite players; as such, for both groups, the median score was 51% with the lowest scores on the supplement section (7). The lack of knowledge improvement between elite level professional players and sub-elite level athletes, a category under which college students fall into, supports the idea that lack of nutrition knowledge is universal to athletes of all levels. Furthermore, the scores are strikingly below the Torrhes-McGehee benchmark of 75%, highlighting the need for improved knowledge.

Finally, a 2017 study by Zuniga and colleagues surveyed 71 Division 1 athletes to better elucidate their levels of sports nutrition knowledge, nutrition information resources, and dietary quality (17). Participants filled out a 7-item questionnaire that was developed and used in a prior study to assess athletes' understanding of macronutrients, micronutrients, alcohol, and recovery as they related to sport. The questionnaire contained true or false questions with the option of selecting 'unsure'. Similar to the previous studies reviewed, scores indicated that overall, nutrition knowledge was low. This conclusion can be drawn from a high prevalence of 'unsure' responses in addition to incorrect responses. Athletes especially lacked knowledge about carbohydrate function and the role of fat in the diet.

The chart below synthesizes these results.

Table 1: Synthesis of research exploring athletes' nutrition knowledge (1,7,12,16,17)

	Population	**Mean Score/ Questionnaire**	**Lowest Areas of Knowledge**
Torres-McGehee, T. M., Pritchett, K.L., Zippel, D., Minton, D. M., Cellamare, A., Sibilia, M. (2012)	College athletes	54.9%/ 20 pt sports nutrition questionnaire	Weight management, eating disorders
Weeden, A.M., Olsen, J., Batacan, J.M., Peterson, T. (2014)	Division 1 collegiate athletes	56.4%/ 65 item Nutrition Knowledge and Behavior questionnaire	Weight management, supplements
Zuniga, K.E., Downey, D.L., McCluskey, R., Rivers, C. (2017)	Division 1 collegiate athletes	Mean score unavailable but poor performance/ 7 item nutrition questionnaire	Macronutrients
Lohman, R., Carr, A., Condo, D. (2019)	Elite and sub-elite Australian football players	51%/ 88 item sports nutrition questionnaire	Supplements
Blennerhassett, C., McNaughton, L. R., Cronin, L., Sparks, S. A. (2019)	Ultra endurance athletes	68.3% ± 9.5%/ Ultra-Q	Fluids, supplements

Overall, these results show that many athletes, particularly collegiate athletes, have low levels of sports nutrition knowledge, which highlights the need for better education. There is also a recurring theme that athletes lack knowledge on topics of weight management and supplements. The fact that all studies share an athletic population and a questionnaire to assess nutrition knowledge lend support to comparability; however, the variability is survey instrumentation, type of athlete, year, and region in which data was collected may be reflected in differences in outcomes. Regardless, it is clear that both overall and within the more specific areas of weight management and supplements, athletes have inadequate sports nutrition knowledge.

Dietary Quality

Diet quality is a term that describes the extent to which one's diet supports health and performance. It can be quantitatively assessed by the level at which it aligns with dietary guidelines. Karen Collins of the American Institute for Cancer Research offers a three part scoring system on which to assess diet (19). According to this system, a high-quality diet gets a larger portion of its calories from wholesome food, helps maintain a healthy weight, and includes food choices and quantities that meet recommended goals (19). In college athletes, another component of a high-quality diet might be one that has a positive influence on training, performance, or recovery. Diet quality is an area of interest in collegiate athletics because it offers insight into how their nutritional habits could be affecting personality, performance, recovery, or injury in sport.

Researchers in a 2015 study evaluated diet composition and body mass index of 138 collegiate athletes (15). To assess diet quality, participants completed the Block 2005 Food Frequency Questionnaire, which contained questions about eating frequency and portion sizes of over 100 foods. Results were analyzed to show macronutrients, micronutrients, and serving sizes. The Healthy Eating Index 2005 then assessed how far diet correlated with U.S. federal guidelines. The results indicated a positive correlation between percent body fat and diet quality such that as percent body fat increased by gender, the diet score as determined by the Healthy Eating Index (HEI) 2005 improved. Results yielded gender differences, as females had significantly greater HEI scores than males, but consumed significantly fewer calories than recommended. Men, on the other hand, consumed significantly more calories than recommended. Another key finding was that men in ball sports had significantly better diet quality than men in sports that required a leaner body type. As such, cross country athletes had less nutritionally sufficient diets than athletes in other sports. Taken as a whole, diets were sufficient in Vitamin C, calcium and iron, but low in fruit and fiber, high in sodium, and high in solid fats, alcohol, and added sugars (SoFAS) (15). These findings may be explained by previous research that show athletes have many misconceptions about the types and quantities of foods they should be eating (9). They may also be explained by low levels of nutrition knowledge.

Another study assessed dietary quality through a different mechanism than that of the previous study: instead of using a questionnaire to gauge food recall, dietary habits were collected through the use of a 3-day food record, 24-hour recall, and nutrition questionnaire (10). With these methods, participants were less reliant on memory to record diet and there was less systematic error present. In applying this format, Shriver and colleagues, the authors of this study, assessed the dietary intakes and eating habits of female collegiate athletes. Results from the food recall journal demonstrated overwhelmingly negative dietary patterns. The energy intake for 91% of participants was significantly lower than their energy requirements (10). Also, on average, participants did not meet the minimum recommended sports nutrition requirements for carbs (5 g/ kg/ day) or fat (35%) but did for protein (1.2 g/ kg/ day). However, half of the participants consumed less PRO than recommended. Finally, 27% of female athletes did not have a regular breakfast (10). The questionnaire illustrated that most athletes were aware of their poor dietary habits, as 56% of participants ranked their diet as ‘fair’ or ‘poor’. These poor dietary patterns can be linked to lack of nutritional knowledge, as demonstrated in the previous section. Perhaps athletes were not well informed of the best ways to improve their diets and are unclear where to start looking amidst the momentous number of oftentimes conflicting sources on the internet. In this situation, nutrition knowledge would be a coherent solution for improving dietary quality.

These studies provided different ways to assess dietary quality in college athletes. They came to different conclusions that reflected larger truths about dietary quality. Both support the idea that college athletes should improve their dietary quality to elicit more healthful outcomes and performance-related benefits.

Problem statement

Lack of nutritional knowledge is evident among college athletes, but assessments of nutrition knowledge and dietary habits are unknown in female collegiate cross country runners.

Purpose Statement

The purpose of this study is twofold:

1. To accurately measure and assess the level of sports nutrition knowledge in female collegiate cross country runners.
2. To explore their dietary quality with regard to several key macronutrients and micronutrients.

Research Question

What are qualitative assessments of sports nutrition knowledge and dietary quality in female collegiate cross country runners?

Hypothesis

Female collegiate cross country runners have poor sports nutrition knowledge and a diet deficient in many key nutrients.

Definition of Terms

Sports nutrition: How the amount, type, and timing of food intake can promote health, performance, and recovery from sport.

Nutrition knowledge: The knowledge of concepts about health and wellness, disease prevention, and human performance as it relates to nutrition.

Dietary quality: A term that describes the extent to which one's diet supports health and performance.

Energy expenditure: The amount of energy a person needs to carry out physical functions such as breathing, circulating blood, digesting food, or exercising.

Adequate nutrition knowledge: A score of 75% or higher on the 20-item Sports Nutrition Questionnaire, as seen in the Torrhes-McGehee study

Inadequate nutrition knowledge: A score of lower than 75% on the 20-item Sports Nutrition Questionnaire, as seen in the Torrhes-McGehee study

Food tracking/ Dietary Tracking: Making note of everything one consumes in a particular time frame by either journaling diet or entering it into a food tracking device. Most of the time, a food tracking program will subsequently be used to synthesize the macronutrient and micronutrient composition of the diet.

Summary

Distance runners are a unique population of athletes that need especially high levels of iron, calcium, vitamin D, and kcals. To perform optimally, distance runners should have good dietary habits. A strong relationship between nutrition knowledge and dietary habits is indicative that learning is an important element of improving diet; healthier dietary choices ultimately support their health, performance, and reduce chance of injury. Knowledge levels can be assessed through administering questionnaires verified by sports nutrition professionals. 75% is a commonly used metric to indicate the minimum score needed for a person to have adequate nutrition knowledge. The studies addressed have found that most athletes have subpar amounts of nutrition knowledge. Dietary quality can be determined by questionnaires, interviews or self-administered dietary tracking. Most studies have found that athletes' diets are somewhat insufficient. If nutritional knowledge does affect dietary outcomes, then education would be an effective modality to change behavior as it relates to diet. Studies have indeed suggested that nutrition education interventions positively influence dietary habits.

Methodology

Study Design

This is a descriptive study in the form of qualitative research.

Population, Sample, and Sampling Techniques

The population consists of Division II women's cross country athletes. This study has taken a convenience sample of 12 runners on the Florida Southern College women's cross country team.

Inclusion Criteria

All participants were on the roster of the Florida Southern women's cross country team at the time of sampling. They were between the ages of 18 and 23. No injuries were present in the athletes at the time of sampling. The runners had no prior history of eating disorders. Participants signed an informed consent before taking part in the study, which covered risks, benefits, confidentiality, and the study's purpose and methods (see Appendix B).

Exclusion Criteria

Participants were excluded if they were not current members of the Florida Southern women's cross country team or if they declined to participate. Participants were also excluded if they had an incomplete questionnaire or missed a day of dietary tracking.

Methods

Participants were recruited from the Florida Southern Women's cross country team via messaging on the GroupMe app. A script of written solicitation may be found in Appendix F. A 30-item sports nutrition knowledge questionnaire assessed the topics of energy intake, macronutrients (carbohydrate, fat, protein), and micronutrients (Vitamin D, iron, Vitamin C, calcium, and water) (see Appendix A). Each item contained a statement with three possible response selections: “true,” “false,” and “unknown”. This questionnaire was modeled after a 2008 study by Theresa Dvorak and reviewed by two exercise science faculty for face validity (5). At the end of this survey, demographic data was collected, including age, class, major, injury history, and prior sports nutrition education. The survey was delivered through an online platform called Survey Monkey and took approximately 15-20 minutes to complete. Participants did not have access to any outside resources to help them respond to items. They were encouraged to select the answer option “unknown” instead of guessing true or false.

Diet quality was assessed through 3 non-consecutive days of dietary tracking, which occured on 2 week days and 1 weekend day. Participants entered all food selections, portion sizes, beverages and supplements consumed a given day into the Automated Self-administered 24-hour (ASA-24) Dietary Assessment tool, an online tool that enables 24-hour food recalls of meals, beverages, supplements, and snacks (see Appendix D). The device provided a reference for portion sizes to help them more accurately recount their diets (see Appendix C). To report a meal or snack, participants found the items eaten, added details (such as additions), and repeated until all meals and snacks were entered. Then, they reviewed the day’s food log and added any missing meals or snacks. They were subsequently taken to a page that asked questions about commonly forgotten items before accessing the final step, in which they were asked a question about their usual intake. Appendix D provides an ASA-24 Participant Start Guide graphic that comprehensively relays this information. Each food recall took approximately 30 minutes to complete. The ASA-24 generated a data report for a participant’s daily intake of various macronutrients, micronutrients, and food groups (see Appendix E). This was downloaded and assessed after data collection was completed.

There were two rounds of data collection, occurring two weeks apart. Multiple series took place to better accommodate participants' schedules and increase participation. The first data collection series took place November 15th to 21st and the second was November 29th to December 5th. Each bout of data collection had four total research sessions, but only the first was conducted in person. Research session 1 had three goals: collect signatures on an informed consent, have participants complete the nutrition knowledge questionnaire, and familiarize participants with the ASA-24. The purpose, benefits, risks, and methods of the study were described verbally, and participants were allowed an opportunity for questions. They read and signed an informed consent, which further detailed this information (see Appendix B). The Sports Nutrition Knowledge Questionnaire was explained orally, with several key points emphasized as described in Appendix G. Then, the questionnaire was delivered via group messaging and accessed through a link to Survey Monkey (see Appendix A).

Once everyone had completed the survey, participants were sent another link to the ASA-24 demo website. The researcher explained the purpose of the ASA-24, along with how to access and input food logs. More details about this oral presentation can be viewed in Appendix G. Participants were encouraged to practice making food, beverage, and supplement entries into the website and ask questions. Participants were given a randomly generated username and password to log into the ASA-24 respondent website. Then, on three assigned days (two weekdays and one weekend day), participants entered their daily food diaries into the ASA-24 website. The GroupMe app was used to provide reminders on the assigned days participants engaged in food tracking. Later, a survey was conducted to collect data about participants' body weights in order accurately assess dietary quality.

Descriptive statistics were used to assess knowledge and dietary quality. Nutrition knowledge scores were assessed and compared according to nutrient, age, and class. Scores were considered "adequate" if they met the 75% threshold set by Torres-McGehee (12). Dietary recalls were qualitatively assessed by comparing the nutrient levels in food logs to current sports nutrition recommendations. An encapsulation of daily recommendations is as follows:

1. Energy intake has a daily requirement of >45 kcal/kg fat free mass + energy spent during physical activity (4). This recommendation is specific to female endurance runners.
2. Carbohydrate recommendations are 6-10 g/kg/day for athletes engaged in an endurance program (1-3 hrs/day of moderate to high intensity activity) (11,14).
3. Protein intake should be within 1.2-1.6 g/kg/day, a recommendation specific to female endurance runners (4,11,14).
4. Fat intake between 20-35% of daily intake is optimal for endurance athletes (11,14).
5. Iron intake should be at least 18 mg/day for pre-menopausal female endurance athletes (4).
6. Daily requirements for calcium are at least 1000 mg (4,11). Recommended values increase to 1,500 mg for athletes with low energy availability or menstrual dysfunctions. Because this was not determined in this study, 1,000 mg was used as a reference point.
7. Vitamin D requirements vary according to institution, with minimum daily intake ranging from 600 IU/day to 1500-2000 IU/ day. Determining Vitamin D requirements for optimal health and performance is a complex process. For this study, 1,000 mg was used as a reference point (8,11).
8. Recommended daily intakes of Vitamin C are greater than or equal to 75 mg (2,11).

9. 2.0 liters/day of water is recommended for adult women (4). For athletes, the water lost during physical activity should be added in recommendations. Because sweat loss rates are highly variable, 2.0 liters was used as a reference point.

A methodology flowchart can be viewed in Appendix H.

Results

The Sports Nutrition Knowledge Questionnaire (SNKQ) and 3-day food log were completed by 12 of 17 eligible respondents, all of whom were members of the women's cross country team at Florida Southern College. The average age of participants was 19.3 ± 1.4. There were far more underclassmen (76.92%) than upperclassmen (23.08%). Participants came from an assortment of majors, the most common being exercise science, education and psychology. A few participants were double majors. While no current injuries existed in the sampling population, most had a history of various sports-related injuries, the most common being shin splints (23.08%) and stress fractures (23.08%). Each participant averaged 2 ± 1.7 previous sports-related injuries.

70% of participants reported receiving education related to sports nutrition, while 30% indicated they had received no prior education in sports nutrition. Modes of education included high school classes (7.69%), collegiate classes (23.08%), collegiate Wellness Center classes (23.08%), individual research (23.08%), and nutritionist sessions (7.69%). See Tables 2 and 3 for more information pertaining to participant characteristics.

Table 2. Participant Characteristics

Characteristics		*N*	Percentage (%) of Respondents
Age (Mean ± SD)	19.3 ± 1.4		
Gender			
	Female	12	100
Sport			
	Cross Country	12	100
Class Ranking			
	Freshman	5	38.46
	Sophomore	5	38.46
	Junior	1	7.69
	Senior	2	15.38
Major*			
	Criminology	2	15.38
	Exercise Science	3	23.08
	Education	3	23.08
	Psychology	3	23.08
	Nursing	1	7.69
	Political Science	1	7.69
	Accounting	1	7.69
# of Sports-Related Injuries	2 ± 1.7		
Sports-Related Injuries**			
	Cuboid bone syndrome	1	7.69
	Labral tear	1	7.69
	Patella Tendonitis	1	7.69
	Shin Splints	3	23.08
	Snapping Hip Syndrome	1	7.69
	Stress Fracture	3	23.08
	Stress Reaction	1	7.69
	Strain	1	7.69
	Sprain	1	7.69

*percentages do not add to 100% due to double majors
**percentages do not add up to 100% because many participants have a history of multiple injuries

Table 3. Previous Nutrition Education

Type of Course/ Education Program	Percentage (%) of Respondents
High School Classes	7.69
Collegiate Classes	23.08
Wellness Center Classes	23.08
Individual Research	23.08
Nutritionist Sessions	7.69
None	30.77

Part 1: Nutrition Knowledge

Results showed participants achieved an average score of 74.9 ± 7.6 on the SNKQ. The highest score was 83% and the lowest score was 60%, eliciting a range of 23%. 10.3% of responses were marked unsure, while 14.9% of responses were incorrect. This is represented by the visual in Figure 1.

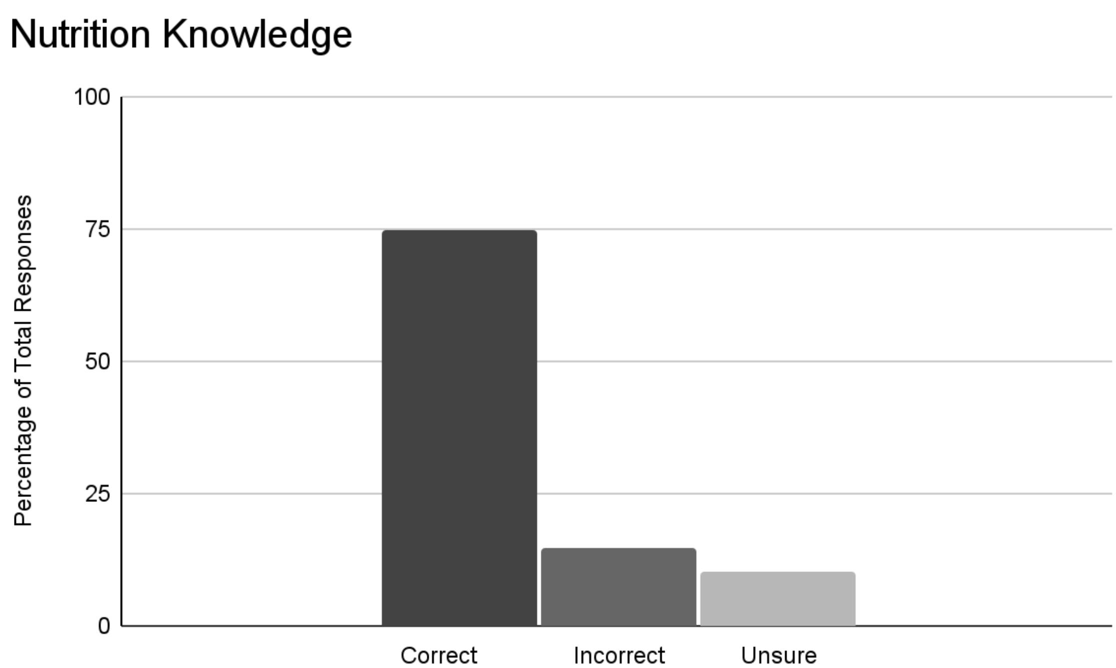

Figure 1. This graph displays a visual of the percentage of total responses marked correct, incorrect, and unsure on the Sports Nutrition Knowledge Questionnaire. 74.86% of responses were correct, 14.88% were incorrect, and 10.26% were marked unsure.

Items were divided by the nutrient they represented. Table 4 shows the breakdown of correct, incorrect, and unsure responses according to nutrients representing various items in the SNQK. Carbohydrates made up the greatest percentage of correct responses and lowest percentage of incorrect and unsure responses. Contrastingly, Vitamin D offered the lowest percentage of correct responses and the highest percentage of incorrect responses. The highest percent of responses marked unsure were from Fat, with Vitamin C less than a point behind. A visual representation of the average scores by construct may be viewed in Figure 2.

Table 4. Nutrition Knowledge

	% Correct	% Incorrect	% Unsure
Overall	74.86%	14.88%	10.26%
Calories	76.92%	14.29%	8.79%
Carbohydrate	94.23%	1.92%	3.85%
Protein	64.62%	24.62%	10.77%
Fat	73.08%	5.78%	21.15%
Iron	57.69%	26.92%	15.38%
Calcium	69.23%	15.38%	15.38%
Vitamin C	61.54%	17.95%	20.51%
Vitamin D	48.72%	43.59%	7.69%
Water	76.92%	17.31%	5.77%

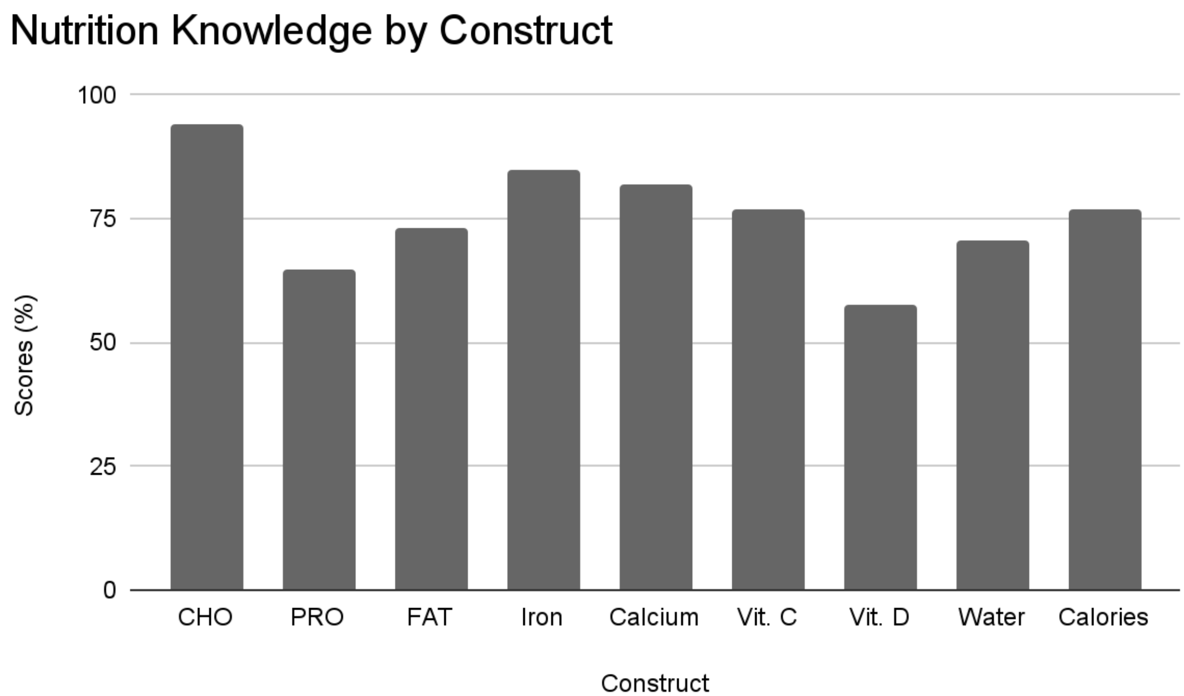

Figure 2. The above visual shows how scores are divided by items representing various nutrients. As seen, items pertaining to Vitamin D attained the lowest average score (48.7%), while items relating to Carbohydrate attained the highest average score (94.23%).

As seen in Figure 3, upperclassmen overall had higher scores than underclassmen. Juniors had the highest average score (83.3%) and freshmen had the lowest (72.7%). Additionally, as demonstrated by Figure 4, a trend existed by which the older the respondent, the higher their level of sports nutrition knowledge. Respondents 18 years in age appeared to score lower, on average, than all other ages (74.2%). Scores increased by each year in age, culminating in a score of 80% for age 22.

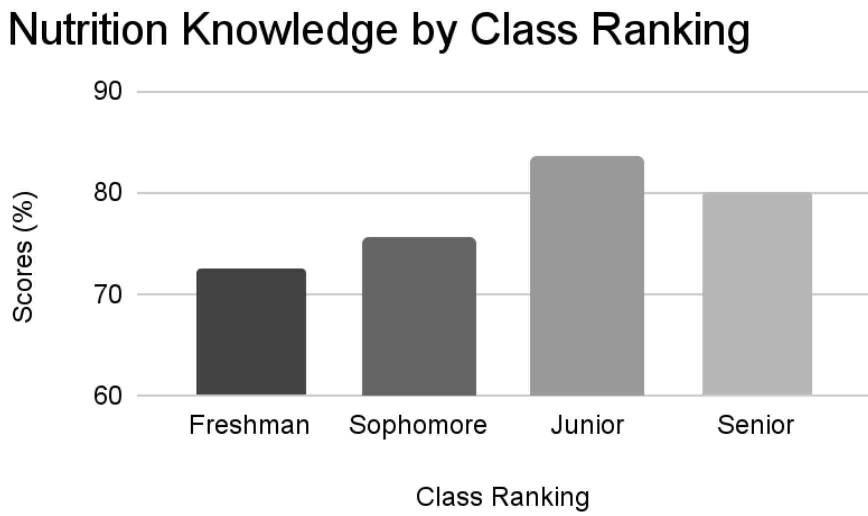

Figure 3. This graph classifies nutrition knowledge according to class ranking. On the x-axis, there are four class rankings (freshman, sophomore, junior, senior), each represented by a bar. The y-axis represents the average score each class achieved on the SNKQ. Freshman achieved an average score of 72.7%, sophomores scored 75.32%, juniors scored 83.3%, and seniors scored 80.0%.

Figure 4. This graph shows how scores in the SNQK vary by age. Displayed on the x-axis is age, in years, and SNKQ scores, in percent, were shown on the y-axis. Age 18 scored 74.2%, 19 scored 74.6%, 20 scored 76.7%, and 22 scored 80%. Thus, scores increased slightly with age.

2 items relating to Vitamin D and water were the most commonly missed questions, with only 15% of participants selecting the correct response. Items relating to calories, carbohydrates, protein, fats, Vitamin D, iron, and water tied for the most correct responses, each receiving an average score of 100%. Calories, carbohydrates, iron, and water contained more items that received an average score of 100% than those relating to protein, fat, and Vitamin D, as they each accounted for two items as compared to just one.

Dietary Quality

Food logs were assessed in terms of 9 different nutrients: calories, carbohydrate, fat, protein, calcium, iron, Vitamin C, Vitamin D, and water. Quality was assessed by comparing nutrient levels with current nutrient recommendations in the literature (see Methodology). There were 36 total food logs, as 12 participants completed 3 each. As shown in Figure 4, the highest percentage of food logs to fit within recommendations was for water (63.9%), while the lowest percentage of food logs to fit within recommendations to fit within recommendations was for Vitamin D (5.55%). Calories were also low, as just 3 out of 36 food logs met the minimum recommendations for carbohydrate intake (6g/kg/day). Less than 25% of food logs met suggested values for calories, carbohydrates, Vitamin C and Vitamin D. Additionally, iron and calcium were beneath 50% of food logs to meet the suggested values.

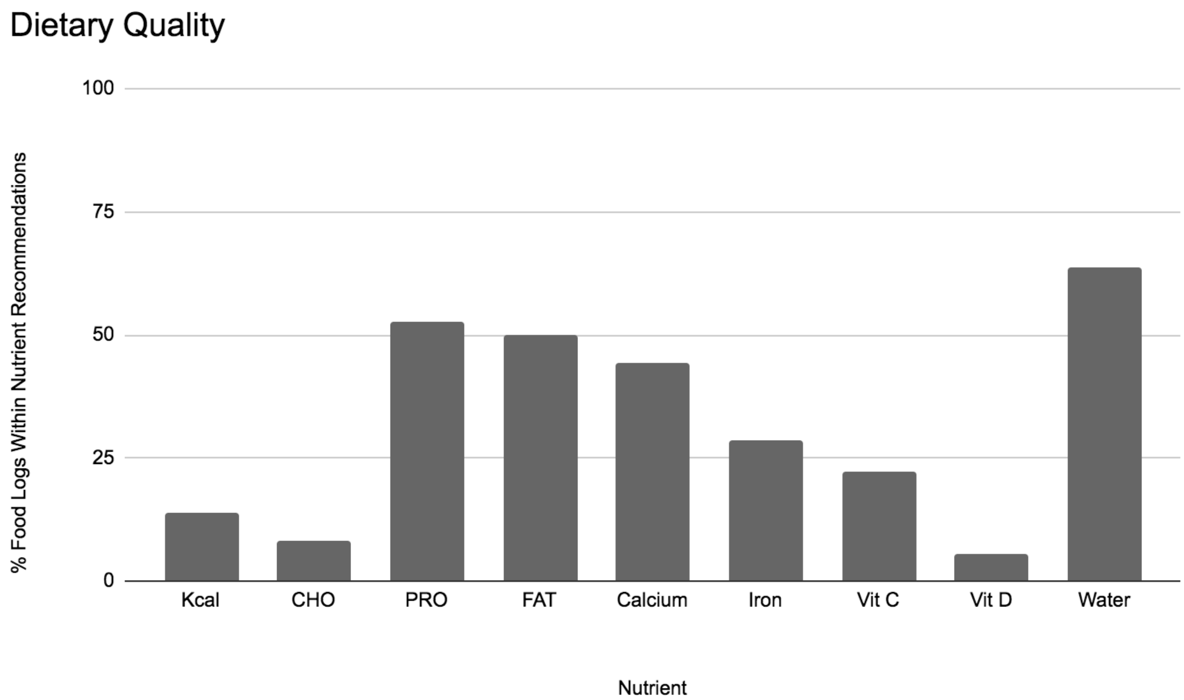

Figure 4. This graph showed the percentage of food logs that met nutrient recommendations for 9 different nutrients (calories, macronutrients, and select micronutrients). On the x-axis, the nutrient of interest is labeled under its corresponding bar. The y-axis contains the percentage of scores that fall within nutrient recommendations. As seen, the highest percentage of food logs (63.9%) met the recommendations for water, while the lowest percentage (5.55%) met the recommendations for Vitamin D.

Table 5 shows the percentage of participants with sufficient intake for each nutrient, in addition to the daily mean nutrient intake for each category. Nutrients could not be compared with each other without accounting for recommendations since the nutrient benchmarks and units of measure were incomparable. No intakes exceeded recommended intakes; thus, only those who fell beneath nutrient requirements failed to meet them. This trend persisted, regardless of nutrients.

Table 5. Dietary Quality

Nutrient	% of Participants with Sufficient Intake	Daily Mean Nutrient Intake
Calories	13.89%	1880.82 kcal
Carbohydrate	8.33%	235.13 g
Protein	52.78%	71.75 g
Fat	50.00%	75.64 g
Iron	28.57%	14.91 mg
Calcium	44.44%	967 mg
Vitamin D	5.56%	210.34 UI
Vitamin C	22.22%	54.53 mg
Water	63.89%	1443.56 mL

Discussion

Nutrition Knowledge

Nutrition knowledge exactly met the 75% benchmark for adequate nutrition knowledge set by Torres-Mcgehee and colleagues (12). For specific nutrients, knowledge was adequate for carbohydrate, iron, Vitamin C, calcium, and calories and inadequate for protein, fat, Vitamin D, and water. These results are markedly different from other studies, which suggest collegiate athletes have inadequate nutrition knowledge (1,7,12,16). A study by Torres-Mcgehee and colleagues sampled college athletes with a 20-item nutrition questionnaire and found scores at 54.5% (12). Similarly, Lohman and colleagues sampled Australian football players with an 88-item questionnaire and found an average score of 50% (7). Weeden sampled Division(16) I collegiate athletes with a 65-item sports nutrition questionnaire and found results similarly low (56.4%). The reason for this discrepancy could be better previous nutrition education, more sources of prior nutrition education, an 'easier' questionnaire, or the specificity of the population (female collegiate cross country athletes). In the literature, athletes scored lowest on macronutrients and fluids. Opposingly, this study demonstrated a trend of higher macronutrient scores than micronutrient. Yet, protein and water were relatively low.

Dietary Quality

Dietary quality was poor for all nutrients, and food logs exceeded meeting 50% of nutrient recommendations for only two nutrients (protein and water). Former studies show that athletes have a low caloric intake, high sugar diets, and diets low in carbohydrate and fat (9,10,16). The current study confirms these results and goes further, showing that athletes are also deficient in many micronutrients (iron, calcium, Vitamin C, Vitamin D). No athletes exceeded recommendations. All who did not meet them were inadequate.

Conclusion

This study examined the dietary habits and sports nutrition knowledge of Division II female collegiate cross country athletes. The results of this revealed that cross country runners have adequate sports nutrition knowledge, but just barely over the 75% mark set by Torres-Mcgehee and colleagues (12). However, respondents scored lower than this marker on many individual nutrients (protein, fat, Vitamin D, water), thereby demonstrating inadequate sports nutrition knowledge in specific contexts. Scores were higher among upperclassmen and lower among underclassmen. Participants knew the most about carbohydrates and the least about Vitamin D. These key findings fill in a gap in the literature relating to nutrition knowledge in female collegiate cross country runners.

Dietary quality was found poor in the sample. Less than half of food logs met recommendations for several key nutrients: calories, carbohydrate, calcium, iron, Vitamin C, and Vitamin D. The fewest number of participants met recommended ranges for Vitamin D, while the most met recommendation values for water. Knowledge did not appear to be related to dietary quality, but further studies will be needed to confirm this. Results proved vital in revealing specific trends in nutrient and energy deficiencies in female collegiate cross country runners. These trends may be related to performance, health, and injury status. Additionally, the act of nutrient tracking may have encouraged dietary awareness in the sample of cross country runners being assessed.

This study may be used in future recommendations for improving the diets of female collegiate cross country runners and developing strategies to prevent nutrient deficiencies. For instance, if most participants are low in iron, this study could be used as a rationale for recommending female collegiate runners to get their iron levels checked or engage in their own form of dietary tracking. In doing so, runners could modify their own diets to support the addition or reduction of certain nutrients.

An educational intervention may be developed based on the areas of sports nutrition knowledge in which athletes score lowest. Examining whether dietary habits are related to nutrition knowledge will help determine whether education is a viable way to improve athletes's day-to-day dietary habits. If significant correlations between these two factors arise, the next step would be to implement a nutrition education program in this population. Sports nutrition knowledge and dietary habits could be compared before and after the addition of this intervention.

Limitations

There are several limitations of this study, the first being the sample size. The small sample size (n=12) creates low external validity. This may affect the reliability of results because it leads to higher variability, which may lead to bias. The small size of the sample means it is less representative of the total population of collegiate female cross country athletes. Additionally, all athletes are from a single college (Florida Southern), which limits the generalizability of results to other universities.

Another limitation is the time point in which data was collected, which relates to a concept called dietary periodization. This sports nutrition concept describes how an athlete's diet should change according to one's goals, training status, and competition demands (11). The intensity, duration, and frequency of training change throughout the season to support the goals that an athlete and their coach have established. Relative daily energy demands and nutrient needs are higher when the athlete is training at a higher volume, which typically occurs earlier in the season. Late into the season, when the current data collection occurred, volume was lower and training sessions were shorter in duration and frequency. As a result, energy and macronutrient needs were lower. Thus, participants' nutrient needs may be skewed towards the lower end of recommended ranges. Low energy and carbohydrate intake may in part be explained by the time in season at which data collection commenced. The discrepancy between the time points at which data was collected further complicates this matter. Data was collected at two time points: November 15th to 21st and November 29th to December 5th. While only two weeks apart, participants were still in-season during the first cycle of data collection and out of season by the second cycle. The drop in training intensity and volume from cycle 1 to 2 means that nutrient and energy needs also dropped. Thus, energy intake and nutrient needs were not comparable between sessions.

Dietary quality assessments were developed based on a 3-day snapshot of participants' diets. An individual's dietary choices are highly variable and what they consume can drastically change from one day to the next. Often, food selections are influenced by schedule, convenience, hunger, and mood, and may not reflect a participant's 'ideal' diet or typical dietary habits. As such, more days of dietary tracking along an extended timeline spanning the entirety of the season would more accurately reflect dietary dietary quality. A 3-day snapshot of diet is brief. Thus, the current study may not accurately represent athletes' typical dietary habits and how diet quality emerges and evolves throughout the cross country season.

Finally, the dietary quality analysis formulas are limited by what is currently known and recommended in the literature and sport organizations such as the ACSM. Many of the micronutrient formulas were not athlete-specific and all macronutronutrient formulas were not sport-specific. More formulas and ranges specifically targeted for collegiate female cross country runners would make the dietary quality assessment more precise.

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Appendices

Appendix A: Sports Nutrition Knowledge Questionnaire

1. Consuming 2,000 calories per day would support the needs of a long distance runner.
   a. True
   b. False
   c. Unknown
2. Protein helps build and repair muscle.
   a. True
   b. False
   c. Unknown
3. Carbohydrates (stored as muscle glycogen) are the most important energy source for high-intensity exercise.
   a. True
   b. False
   c. Unknown
4. Oils from plants, fish, nuts, and seeds are considered healthy fats.
   a. True
   b. False
   c. Unknown
5. Common carbohydrate-rich foods are pasta, potatoes, cereal and bread.
   a. True
   b. False
   c. Unknown
6. Athletes can strategically time the intake of carbohydrates before, during, and after their workout to maximize performance.
   a. True
   b. False
   c. Unknown
7. To gain weight, an athlete has to consume more food (energy) than what is used during exercise and to body functions.
   a. True
   b. False
   c. Unknown
8. Most athletes require about four times more protein than non-athletes.
   a. True
   b. False
   c. Unknown
9. Endurance athletes are susceptible to low energy availability (ie, not meeting energy needs).
   a. True
   b. False
   c. Unknown
10. An athlete's pre-competition meal should be high in protein.

   a. True
   b. False
   c. Unknown
11. Common foods high in protein include cheese, eggs, and lentils.
   a. True
   b. False
   c. Unknown
12. Fats should comprise 20-35% of an athlete's macronutrient intake.
   a. True
   b. False
   c. Unknown
13. Fat is an important source of fuel at rest and during long duration, lower intensity exercise.
   a. True
   b. False
   c. Unknown
14. Calcium is only naturally occurring in dairy products.
   a. True
   b. False
   c. Unknown
15. Vitamin D can only be absorbed from sunlight.
   a. True
   b. False
   c. Unknown
16. Low levels of sodium in the blood, along with dehydration, can cause muscle cramps.
   a. True
   b. False
   c. Unknown
17. Calcium and Vitamin D are important for bone health.
   a. True
   b. False
   c. Unknown
18. Lentils, soy milk, and sardines are good sources of calcium.
   a. True
   b. False
   c. Unknown
19. Iron deficiency can cause increased fatigue during exercise and delay recovery after practice and competition.
   a. True
   b. False
   c. Unknown
20. Feeling tired in the middle of a workout may be a sign of not consuming enough calories.
   a. True
   b. False
   c. Unknown
21. Iron is found in meat, dark green vegetables, eggs, and fortified cereal.

   a. True
   b. False
   c. Unknown
22. Oranges, tomatoes, and cantaloupe are good sources of Vitamin C.
   a. True
   b. False
   c. Unknown
23. Athletes should only drink water when they are thirsty.
   a. True
   b. False
   c. Unknown
24. Male and female athletes are at equal risk of under-fueling and low energy availability.
   a. True
   b. False
   c. Unknown
25. It is more necessary to drink fluids before competition or training than during competition or training.
   a. True
   b. False
   c. Unknown
26. Hydration levels are only impacted by what you drink, not what you eat.
   a. True
   b. False
   c. Unknown
27. How much an athlete sweats can be measured from the change in body weight before and after exercise.
   a. True
   b. False
   c. Unknown
28. Vitamin C assists with the absorption of iron.
   a. True
   b. False
   c. Unknown
29. Proteins, carbohydrates and fat all provide the same amount of calories per gram.
   a. True
   b. False
   c. Unknown
30. Vitamins and minerals provide energy (calories).
   a. True
   b. False
   c. Unknown

Appendix B: Informed Consent

I, ____, agree to participate in the research pertaining to the relationship between sports nutrition knowledge and dietary quality in female collegiate cross country runners. This research is being conducted by Alayna Goll, who can be reached at alaynagoll@gmail.com.

The following points have been explained to you:

1. Your participation in this study is voluntary.
2. You can withdraw your participation from this study at any time without penalty.
3. If you withdraw your consent, your data will not be used.
4. The purpose of this study is to determine whether there is a relationship between sports nutrition knowledge and dietary choices in collegiate female cross country runners.
5. The procedures will be as follows:
    a. You will be asked to attend an initial research session to learn about the instruments used in this study and better understand the procedures.
    b. You will be asked to complete a 30-item sports nutrition knowledge questionnaire on Survey Monkey.
    c. You asked to track your diet for 3 days.
    d. You will be asked to enter your diet into an online automated assessment tool (ASA-24).
6. There will be 4 sessions throughout the course of a week. The total time involved is 100-150 minutes.
7. The information gathered will be kept confidential.
8. Only the researcher will have access to information. This information will be stored in password protected files. The ASA-24 does not collect any personally identifiable information related to study respondents. Participants access the platform via system-generated usernames and passwords so their names are never embedded within the system. All data entered into the ASA-24 system is protected by an internet browser and transmitted to ASA servers through an additional layer of security.
9. Dissemination of study records presented in public spaces will not use any identifiable information.
10. The expected benefits of this study include revealing gaps in nutrition knowledge, identifying nutrient deficiencies, and supporting the use of education to enhance dietary quality.
11. You are not likely to experience physical, psychological, social, or legal risks beyond those ordinarily encountered in daily life or during the performance of routine examinations or tests by participating in this study.

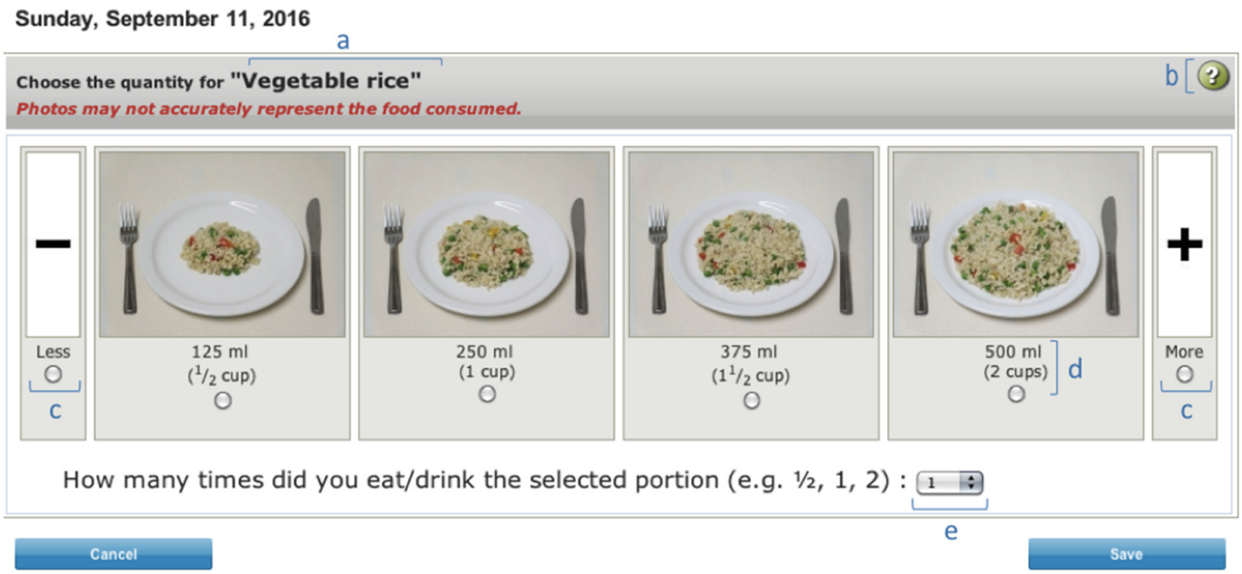
12. The investigator will answer any further questions about the research should you have them now or in the future. The investigator contact information is **alaynagoll@gmail.com**.
13. By signing and returning this form, you acknowledge that you are 18 years of age or older.
14. By signing and returning this form, you are providing consent to participation in this study.

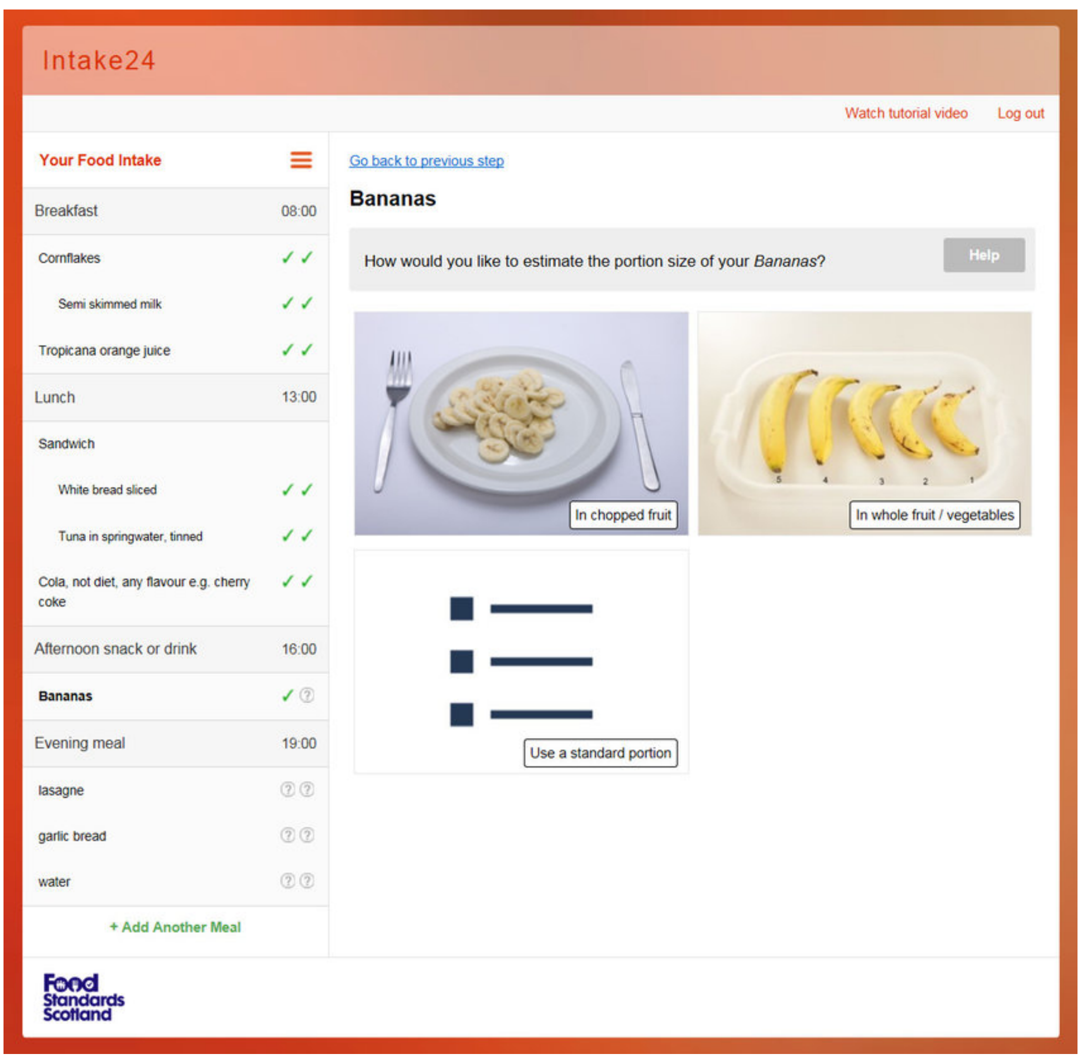
Signature of Investigator Date

Signature of Participant Date

Research at Florida Southern College involving human participants is carried out with the oversight of the Human Subjects Institutional Review Board. Address questions regarding these activities to the HS-IRB Chair, email: fscirb@flsouthern.edu; or Office of the Provost; phone (863)680-4124.

Appendix C: Portion Sizes Reference

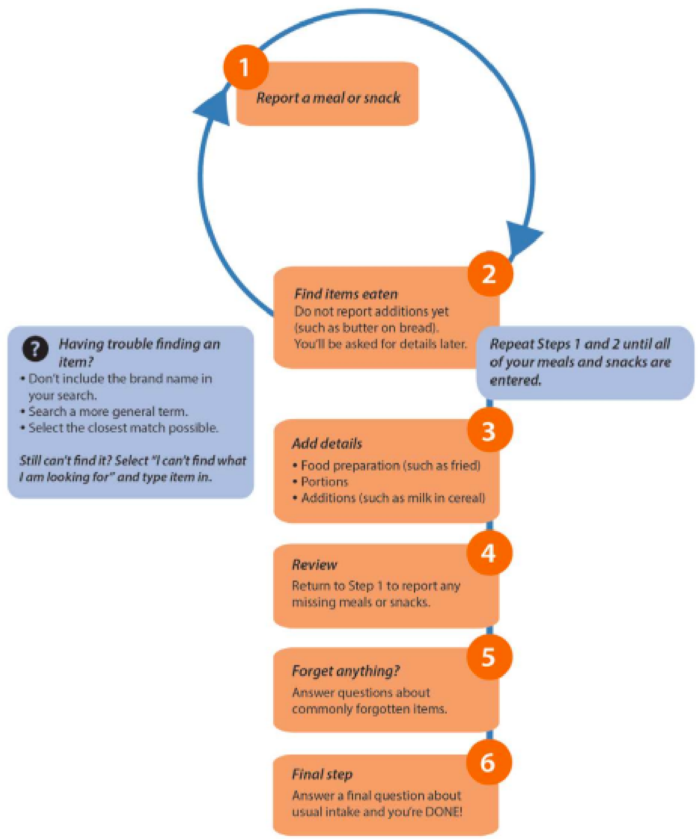




Appendix D: ASA-24 Participant Start Guide

ASA24: Quick Start Guide for 24-Hour Recalls

How the ASA24 system flows for 24-Hour Recalls:



ASA24
Automated Self-Administered 24-Hour Dietary Assessment Tool

ASA24-2016 Participant Quick Start Guide for 24-Hour Recalls

You have been asked to complete a 24-hour dietary recall by using the Automated Self-Administered 24-Hour Dietary Assessment Tool (ASA24).

This 24-hour dietary recall captures detailed information about all foods, drinks, and supplements (including vitamins, minerals, herbals, and other dietary supplements) you consumed from midnight to midnight yesterday, or for the past 24 hours starting from the time you log in (depending on the instructions you receive).

This guide describes the steps you need to follow to complete your 24-hour recall, along with tips and screen shots to help you if you have questions. You can always use the **Help** button at the bottom of the screen if you can't find the answers to your questions here.

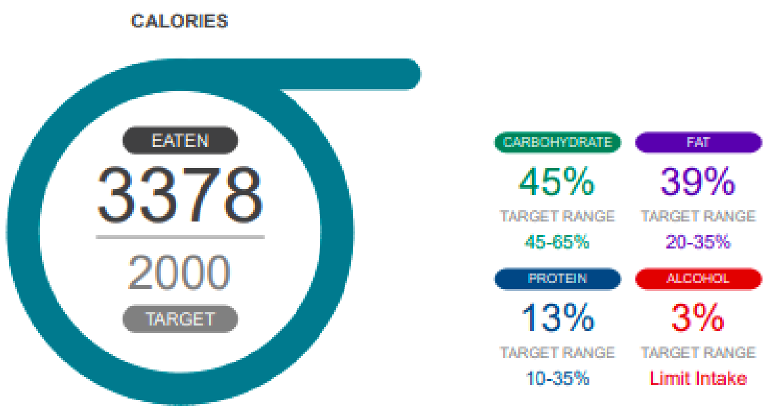
A few tips:

- Allow about 30 minutes to complete your 24-hour recall.
- After 30 minutes of inactivity, you will be automatically logged out of ASA24. Your information will be saved. Depending on the options selected by the person who asked you to complete a recall, you may or may not be able to log back in to finish.
- If you have ever tracked your diet or counted calories using a smartphone or web application ("app"), you will find that ASA24 is quite different. ASA24 captures your total nutrient and food group (such as fruits, dairy) intake. Therefore, it is important that you report all the foods, drinks, and dietary supplements you consumed.
- Also, compared to a web or smartphone app, you might notice that ASA24 has a smaller selection of brand name or restaurant-specific items. If you can't find the exact item you had, **select the closest match** you can find.
- We know that what you eat from one day to the next can be quite different. Please enter only the foods, drinks, and dietary supplements you actually consumed, even if they do not reflect your usual diet.

Appendix E: ASA-24 Nutrition Profile Report

5/21/2021 ASA24 Nutrition Profile Print Preview

Total Calorie Consumption



Calories

Most foods and many beverages contain calories. A person's calorie needs each day depends on factors such as age, gender, height, weight, and level of physical activity. In addition, a need to lose, maintain, or gain weight affects how many calories should be consumed. The target range for percent of calories from carbohydrates, protein, and fat listed here represent the range that is associated with providing adequate intakes of essential nutrients and a reduced risk of chronic disease.

Alcohol

Alcoholic beverage intake is not recommended in the Dietary Guidelines for Americans. If alcohol is consumed, it should be in moderation—up to one drink per day for women and up to two drinks per day for men—and only by adults of legal drinking age. There are also many circumstances in which individuals should not drink, such as during pregnancy.

Sources

2015 -2020 Dietary Guidelines for Americans
(https://www.dietaryguidelines.gov (https://www.dietaryguidelines.gov)) and Dietary Reference Intakes
(https://www.nal.usda.gov/fnic/macronutrients (https://www.nal.usda.gov/fnic/macronutrients)).

Appendix F: Script of Written Solicitation

This script was delivered via email and GroupMe messaging. A similar message was delivered during a women's cross country team meeting. The messaging reflected the fact that the researcher was in regular contact with participants since they are all members of the Florida Southern women's cross country team. The script was delivered as follows:

Hello, everyone,

As some of you may know, I am a member of the Honors Program here at Florida Southern College. As it is my senior year, I am fulfilling the Honors Thesis program requirements by conducting my own original research project. The goal of this research is twofold: it will determine participants' levels of nutrition knowledge and quality of diet, in addition to the relationship between these two variables.

I am asking that you all consider participating in this study. There are no associated or expected risks with participating in this study. The expected benefits include revealing gaps in nutrition knowledge, identifying nutrient deficiencies, and supporting the use of education to enhance dietary quality in college athletes. Confidentiality will be maintained and your information will be kept privately by the researcher in password-protected files. There will be 4 sessions throughout the course of the week, estimated to take approximately 100-150 minutes of your time in total. There is no obligation to participate in this study and you are free to drop out at any time. If interested, please contact me at (239) 240-4834 or alaynagoll@gmail.com. I would really appreciate it if you decided to participate!

Thank you,

Alayna Goll

Appendix G: Oral Presentation Outline- Data Collection Session 1

This includes an outline of a presentation and explanation of the nutrition knowledge questionnaire
delivered in data collection session 1.

- The purpose of this questionnaire is to assess your general knowledge of sports nutrition.
- The questionnaire assesses your knowledge of the following topics: calories (energy), carbohydrates, fat, protein, water, Vitamin C, Vitamin D, calcium, and iron.
- You are encouraged to complete the entirety of the questionnaire.
- Participation is voluntary and you may drop out at any point without penalty.
- If you decide to drop out, your results will not be included in the study.
- This questionnaire should take you approximately 15-20 minutes to complete.
- The questionnaire contains 30 items total. Each contains the answer choices true, false, or unknown. If you do not know the answer to a question, you are encouraged to select the unknown option rather than guess true or false.

This includes a continuation of points made during the oral presentation delivered in familiarization session 1. What follows includes an explanation of the ASA-24, a tutorial on how to use it, and a statement on privacy and participation.

- If you choose to participate, you will compile a set of dietary records in which you will list everything you consumed in a single day into a web-based tool called the Automated Self-Administered Recall System, or ASA-24. This will be your food record of everything you consumed within a given day.
- Food record entries will occur on three separate days (two weekdays and one weekend day) within the span of a week. These days have been predetermined by the researcher.
- On the days you will engage in food tracking, you will record both the amount and type of food or beverage ingested. Food tracking will occur at the end of each designated day.
- Your food records will automatically enter a tracking program that assesses levels of macronutrients, micronutrients, and energy intake.
- To access the ASA-24, you will be given a system-generated username and password. You will use this to enter your food record into the website. The website will be sent to you via the GroupMe app.
- Complete your records at the end of each designated day.
- Allow about 30 minutes to complete your 24-hour recall.
- After 30 minutes of inactivity, you will be automatically logged out of ASA24. Your information will be saved. Depending on the options selected by the person who asked you to complete a recall, you may or may not be able to log back in to finish.
- If you have ever tracked your diet or counted calories using a smartphone or web application ("app"), you will find that ASA24 is quite different. ASA24 captures your total nutrient and food group (such as fruits, dairy) intake. Therefore, it is important that

you report all the foods, drinks, and dietary supplements you consumed.

- Also, compared to a web or smartphone app, you might notice that ASA24 has a smaller selection of brand name or restaurant-specific items. If you can't find the exact item you had, select the closest match you can find.
- We know that what you eat from one day to the next can be quite different. Please enter only the foods, drinks, and dietary supplements you actually consumed, even if they do not reflect your usual diet.
- The ASA-24 will provide you with prompts to help you along with the process of entering the correct foods, beverages, supplements, and portion sizes.
- The participant start guide will be discussed to provide a more in-depth tutorial on how to navigate the ASA-24 interface.
- All participants will be allotted reminders to complete dietary tracking on the designated days through the GroupMe app, email, and in person.
- Participation is voluntary and you may drop out at any point without penalty.
- If you decide to drop out, your results will not be included in the study.
- Data will be stored in password protected files. No personal information about the user or the session is collected or stored by either the researcher or the ASA24 website.
- The researcher is the only one who will have access to these dietary tracking reports. Participants will not see their report which assesses the quality of their diet.
- The results from the ASA-24 will be evaluated to qualitatively assess diet quality and nutrition knowledge in collegiate female cross country runners.
- Any questions should be directed to the researcher at the end of this session. Future questions may be delivered in person, through email, or through GroupMe. The researcher will respond at their first possible convenience.

Appendix H: Methodology