Female Athlete Nutrition Study Secondary Analysis

Relationship of Nutrition Knowledge and Dietary Intake Among Collegiate Female Athletes

by

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ABSTRACT

The assessment and evaluation of dietary intake and nutrition knowledge in female athletes is especially important due to the high prevalence of inadequate intake in this population (Black et al., 2019). This study evaluated 1) the relationship of nutrition knowledge and dietary intake among collegiate female athletes at the National Collegiate Athletic Association (NCAA) Division I, National Junior College Athletic Association (NJCAA), and Club sport levels and 2) the impact of competition level on this relationship as well. Participants (NCAA DI, n=51; NJCAA, n = 36; Club, n = 37) in this study answered two questionnaires, the Nutrition Sport Knowledge Questionnaire (NSKQ) and the Rapid Eating Assessment for Participants (REAP) questionnaire to assess knowledge and dietary intake. Participants also provided anthropometric and demographic information. The NSKQ was scored as a whole and for each of the four subcategories. REAP was scored both by tallying the number of "usually/often" frequency responses and given a numeral score to estimate diet quality. Statistical analysis was conducted using Kruskal-Wallis, Chi-square and Spearman's correlation tests to compare differences within subgroups of participants and evaluate any relationships that may exist between nutrition knowledge and dietary intake with significance set at $p \leq 0.05$. Differences in nutrition knowledge between competition groups were significant, $H(2) = 16.94$, $p < 0.001$. NCAA DI ($p<0.001$) and Club ($p<0.001$) athletes had higher nutrition knowledge than athletes at the NJCAA level. This was true for overall knowledge as well as knowledge subcategories. However, minimal relationships between nutrition knowledge and dietary intake were found. The overall

correlation value was $r_s(118) = -0.10$ (95%CI: -0.28 to 0.08), $p>0.05$. This suggests those with higher nutrition knowledge did not necessarily have better dietary intake. Improvements in the assessment of nutrition knowledge and quick assessment of dietary quality and the relation between both is needed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

REVIEW OF LITERATURE

It has been widely accepted for some time that "performance of, and recovery from, sporting activities are enhanced by well-chosen nutrition strategies" (Thomas, Erdman, and Burke, 2016). Nutrition strategies may include guidance on the proper type, amount, and timing of food and fluid intake, as well as the use of ergogenic supplemental products. The Academy of Nutrition and Dietetics, Dieticians of Canada, and the American College of Sports Medicine recommend all athletes should be referred to registered dietitian nutritionists (RD) for individualized recommendations on a nutrition plan. Improper nutrition intake has been shown to have adverse effects on athletic performance including reduced muscle force, reduced time to fatigue, impaired concentration and skill, and increased muscle soreness (Bergström, Hermansen, Hultman, and Saltin, 1967; Krustrup et al., 2011; Norman, Stobäus, Gonzalez, Schulzke, and Pirlich, 2011). Female athletes, in particular, are also at risk for the female athlete triad, which is a common disorder with three components, including menstrual dysfunction, low energy availability (with or without an eating disorder), and decreased bone mineral density. The female athlete triad not only has immediate negative impacts on performance but also can have long-term health consequences. The prevalence of the female athlete triad is generally unknown, but disordered eating behaviors have been reported in up to 66% of female athletes (Hobart and Smucker, 2000). Assessment of eating behaviors, especially with the Rapid Eating Assessment for Patients (REAP) tool, may be able to identify poor dietary habits and lead to the intervention of a dietitian.

Additionally, to optimize athletic performance and general health, female athletes especially should implement evidence-based nutrition strategies in their diets and training plans. One systematic review reported a weak, positive association (r< .44) in five out of the nine studies included (Heaney, O'Connor, Michael, Gifford, and Naughton, 2011). Therefore, it is reasonable to expect athletes with higher nutrition knowledge would also have better dietary intakes, but few studies have examined this relationship, especially in female athletes (Chapman, Toma, Tuveson, and Jacob, 1997; Frederick and Hawkins, 1992; Rash, Malinauskas, Duffrin, Barber-Heidal, and Overton, 2008; Spronk, Kullen, Burdon, and O'Connor, 2014).

Nutrition and Athletic Performance

Nutrition and athletic performance are inseparable and interact on many levels of performance, including muscle force, recovery, and fatigue. Activity is powered by various energy systems using substrates often provided by or replenished with a person's diet. Substrate availability changes daily and is affected by dietary intake as well as exercise demands. Skeletal muscle has an impressive ability to adapt and regulate energy systems based on fuel availability (Spriet, 2014). It has been shown ingestion of one large dose of protein post-exercise improved the restoration of muscle force and power during recovery (Etheridge, Philp, and Watt, 2008). In this scenario, a single nutrition strategy, post-exercise protein ingestion, was shown to improve participants' ability to recover and perform during consecutive training bouts, which is critical to an athlete's success. It has also been well established that dietary carbohydrates assist in maintaining blood glucose and prolonging fatigue during exercise (Krogh and Lindhard, 1920;

Murray and Rosenbloom, 2018). One study in ten trained cyclists found ingesting carbohydrate solutions increased exercise time to fatigue by about 20 minutes compared to a placebo (Coyle et al., 1983). Prolonging time to fatigue can also positively enhance performance, especially when games and competitions are hours in duration or over multiple days. Nutrition has a strong ability to impact athletic performance and, therefore, nutrition strategies should be incorporated into an athlete's training plan. At a basic level, adequate energy intake is required for athletes to maximize training adaptations and to prevent injury and illness.

Female Athletes

The concept of energy intake and availability has been widely discussed in regard to female athletes. More than 30 years ago, the American College of Sports Medicine identified a triad of disorders emerging in young adult female athletes consisting of disordered eating, amenorrhea, and osteoporosis (Yeager, Agostini, Nattiv, and Drinkwater, 1993). Since then, the female athlete triad has been expanded to include low energy availability with or without an eating disorder and low bone mineral density (BMD) with or without osteoporosis (Souza et al., 2014). The triad is not only detrimental to performance but also general health. Premature losses in bone or impairment in bone formation during a young female's life increases the risk of fracture at a later time and it is not known whether these losses are reversible. While the exact prevalence of the triad is unknown, female athletes may present with one or more components and nutrition plays an integral part in the treatment as well as prevention.

There is a direct relationship with regards to nutrition and energy availability. Energy availability is defined as the amount of dietary energy remaining and available for other metabolic bodily processes after exercise (Loucks, Kiens, and Wright, 2011). Consequences of low energy availability may include impaired ability to build bone, maintain muscle mass, repair damaged tissue, and recover from injury. Low energy availability has been said to be "the primary factor that impairs menstrual dysfunction and bone health in the Triad" (Manroe, Kam, and Loucks, 2007). Evidence for a causal relationship between low energy availability and amenorrhea has been demonstrated through the recovery of reproductive hormone production with supplemental energy in monkeys (Williams, Helmreich, Parfitt, Caston-Balderrama, and Cameron, 2001).

Interestingly, worse sports performance was shown in elite female swimmers with ovarian suppression in comparison with their competitors with regular menstrual cycles (Vanheest, Rodgers, Mahoney, and De Souza, 2014). Another investigation revealed a dose-response relationship between energy availability and hormones that promote bone formation that led researchers to conclude chronic low energy availability may result in irreversible reductions in bone mineral density (Ihle and Loucks, 2004). Low energy availability thus can create a cycle of the interrelated disorders that complete the Triad and have additional negative impacts on health. One research team wanted to determine whether female athletes were aware and actively trying to prevent impairments to bone health. They found no correlation between osteoporosis knowledge, attitudes, and dietary calcium intake (Turner and Bass, 2001). It concerning that female athletes were unaware of their bone health, considering peak bone mass develops during young adulthood and additional negative consequences can arise from poor dietary choices over the long term.

Therefore, female athletes and athletic support staff should prioritize proper nutritional intake to prevent low energy availability and prevent negative influences on health and performance.

Dietary Intake

Evidence in support of prioritizing nutrition intake in female athletes is abundant, yet, it appears many female athletes are not meeting estimated required energy intakes. One Division I National Collegiate Athletic Association (NCAA) university found that 91% of female athletes on the university's soccer, basketball, and track and field teams were not meeting estimated energy needs (Shriver, Betts, and Wollenberg, 2013). This study presented an alarming proportion of young women who were compromising performance and health and indicated the need for emphasis on improving nutrition habits in this population. Few other studies have investigated dietary intake in female athletes, but findings have generally been consistent in that many athletes do not meet recommended dietary intakes. Jonnalagadda and colleagues (2004) examined diets in elite female figure skaters, often seen as a population at risk for eating disorders. They found the average energy intake was significantly below estimated needs, although 30% of participants reported they felt overweight. These investigators also evaluated participant's dieting behaviors and body image and ultimately suggested comprehensive counseling and education should be used to promote adequate and healthy dietary intake.

Further, another study in exercising collegiate females found their energy intakes were within the recommended daily allowance for their age and gender but likely insufficient for their activity level (Brown et al., 2020). Indeed, evidence exists that female athletes are often failing to support their activity levels with adequate nutrition. This poses the question of what prevents athletes from meeting their recommended intakes. Nutrition knowledge is one aspect that likely has a direct influence on an athlete's dietary intake.

Standard methods to evaluate dietary intake include dietary records, 24-hour dietary recalls, and food frequency questionnaires (FFQ) (Thompson and Subar, 2017). Each method has its positives and drawbacks; some are more appropriate for specific situations than others. Dietary records require persons to self-report their intake and can often lead to participants altering food choices, which can lead to inaccurate results. Similarly, the 24-hour recall is dependent on the participant remembering everything they consumed the previous day and can be time-consuming to administer. FFQ methods ask about the usual frequency of consumption of foods for a specified period. Although FFQs collect less detail than the previous methods, overall nutrient intake can be estimated and are easy and convenient to administer. FFQs commonly used are the Block Questionnaire, the Willett Questionnaire, and the Rapid Eating Assessment for Patients (REAP). The Block Questionnaire was originally developed by the National Cancer Institute and contains 110 food item questions ("NutritionQuest," 2014). The Willett questionnaire was developed by Walter Willett (2015) and his colleagues at Harvard University and contains questions related to 147 food items and dietary supplements.

In contrast, REAP is a brief questionnaire intended to aid healthcare providers to quickly assess a patient's diet (Gans et al., 2006). The REAP questionnaire has also been previously validated in NCAA athletes to identify healthful and unhealthful eating behaviors (Kurka, Buman, and Ainsworth, 2014). Researchers demonstrated that REAP is a valid tool within NCAA populations and due to variability in collegiate athletes, they should be evaluated for healthful and unhealthful eating behaviors. See table 1 for an overview of dietary intake in athletes.

Table 1

Overview of studies investigating dietary intake in athletic populations

Author	Year	Method	Population	Conclusions
Diet or food records, 24-hour recall and food frequency questionnaires				
Abood et. al	2004	3-day diet records	NCAA DI female soccer players and swimmers (n=30)	Nutrition education intervention resulted in a significant difference in overall positive dietary changes for the experimental group
Brown et. al	2020	3-day food records (4 records total per athlete)	Collegiate female dancers (n=17)	Energy intake was within the recommended daily allowance but may be insufficient for their activity levels
Jonnalagadda et. al	2004	3-day food records, Eating Attitudes Test, Food Preference Checklist	Male (n=23) and female (n=26) elite figure skaters (15±2.6yrs)	Total energy, total fat, and dietary fiber intakes were below recommendations for females
Rash et. al	2008	YAC food frequency questionnaire	Track and Field athletes from two NCAA DI schools (n=113)	Nonsignificant and weak correlation between nutrition knowledge and attitude versus diet quality
Turner and Bass	2001	Self-reported intakes of dairy product consumption per week (FFQ)	Female collegiate athletes (n=114)	Osteoporosis knowledge and dietary calcium knowledge were not correlated with dairy product intake
Shriver et. al	2013	3-day diet record, 24-hour recall, and CAED Nutrition Questionnaire	Female NCAA DI collegiate athletes (n=52)	Only 9% of participants met their estimated energy needs
VanHeest et. al	2014	3-day diet records (7 records total per athlete)	Elite junior swimmers (n=10) (15-17 yr)	Energy status markers were highly correlated with sport performance
REAP questionnaires				
Johnston et. al	2018	REAP-S Questionnaire and Healthy Eating Index-2010 scores	Male (n=24) and female (n=57) omnivores, vegetarians, and vegans	Only significant correlation was between REAP-S diet quality score and fasting plasma glucose; diet quality differed mainly between the omnivore and vegan groups
Mayra et. al	2019	REAP-S Questionnaire	Healthy omnivores and vegetarians (n=33)	No difference in diet quality between vegetarians and omnivores
Robinson	2015	Military Pre-training Questionnaire including a modified version of the Nutrition Component of the REAP	Infantry recruits in the British Army (n=1,960)	Variations in REAP responses correlated with other health behaviors but did not impact injury risk
Turner-McGrievy et. al	2016	Online survey including the Nutrition Component of the REAP	Half-, Full-, and Ultramarathon runners (n=422)	There was no difference between the distance groups' REAP diet score as well as individual REAP food category scores

Nutrition Knowledge

It has been suggested athletes have only slightly higher sports nutrition knowledge than their non-athlete counterparts (Heaney, O'Connor, Michael, Gifford, & Naughton, 2011). Although various methods of evaluating an athlete's level of knowledge exist, results often demonstrate opportunities for nutrition education regardless of the method used (Andrews, Wojcik, Boyd, and Bowers, 2016; Holden, 2018). One previous study conducted within a Division I National Collegiate Athletic Association Institution found an average score of 5.8 out of 11 (53%) when a nutrition knowledge questionnaire was administered to 237 male and female athletes (Rosenbloom, Jonnalagadda, and Skinner, 2002). This study revealed athletes were often aware and familiar with sports nutrition concepts but struggled with the application, possibly due to misconceptions around food and supplements. Another investigation into nutrition knowledge among collegiate athletes, coaches, athletic trainers, and strength and conditioning specialists across multiple NCAA Division I, II, and III institutions found that only 7% of athletes (n=185) scored above 75% on a 20-question sports nutrition knowledge questionnaire (Torres-McGehee et al., 2012). Although results related to athletes' nutrition knowledge vary, poor nutrition knowledge may pose a significant barrier to proper nutrition intake for athletes, which ultimately may prevent optimal performance (Thomas, Erdman, and Burke, 2016).

Methods developed to assess sports nutrition knowledge in athletes include the General and Sports Nutrition Knowledge Questionnaire (GSNKQ) and the Nutrition for Sport Knowledge Questionnaire (NSKQ). The GNSKQ is an 85-question questionnaire formulated by experts in the UK and validated for use in Track and Field athletes (Furber, Roberts, and Roberts, 2017). More recently, Trakman and colleagues (2017) developed a validated 89-question assessment and concluded the tool might be useful in team sports settings. Both questionnaires have been formulated somewhat recently and are similar in overall content, although they differ similarly in how the questions are presented. Each can provide practitioners with insight into an athlete's nutrition knowledge, which can be interpreted to develop more targeted and effective educations and interventions.

However, before assuring nutrition education will be effective and translate into improved dietary practices of athletes, it is helpful to examine the relationship between nutrition knowledge and dietary intake. Limited insight is available into this association and additional information could assist sports dietitians and other coaching staff in supporting young female athletes. In general, studies tend to find a moderately positive correlation between nutrition knowledge and dietary intake. One systematic review determined a significant weak, positive relationship ($r < .44$) that exists between nutrition knowledge and dietary intake (Heaney et al., 2011). The authors acknowledged variability in evaluating nutrition knowledge and intake makes it difficult to compare studies and many other confounding factors may influence behavior as well. Variability in methodology between studies has also resulted in variability in the outcomes. Perron and colleagues (1985) found no correlation between nutrition knowledge and dietary intake in female athletes, but they did find a positive, non-significant relationship between nutrition knowledge and nutrition attitudes. This might suggest as a person gains more knowledge, they will feel more favorable toward nutrition intake, which may impact dietary choices at a later point.

In contrast, another study found a moderate correlation (r= .44, $p<0.01$) between nutrition knowledge and dietary health habits with a stronger relationship in elite compared to non-elite athletes (Harrison, Hopkins, MacFarlane, and Worsley, 1991). This moderate association suggests athletes are somewhat knowledgeable about nutrition, yet, they do not always apply their knowledge when eating at lower competition levels. One study in 943 high school athletes found that, interestingly, female athletes had better nutrition knowledge, 57%±13 for females versus 53%±20 for men, but more inferior food practices than their male counterparts (Douglas and Douglas, 1984). In turn, it is important to acknowledge that other factors influence dietary intake, including access to food, financial resources, and educational sources.

Another insight into track athletes from two different DI NCAA universities revealed no correlations between nutrition knowledge and attitudes (r = .05) and diet quality (r < .01) (Rash, Malinauskas, Duffrin, Barber-Heidal, and Overton, 2008). This team of researchers also discussed the need to address additional factors that interact to influence and predict dietary intake. It is much more common for athletes at the Division I level to have access to a dietitian and other nutrition resources such as meals and snacks provided by the athletic department. It also may be likely the meals provided are of higher nutritional quality compared to meals provided in dining halls or at dining out establishments resulting in higher diet quality. One large DI University showed that nutrition intervention improved nutrition knowledge and increased positive dietary changes in their women's soccer and swim teams, 70% prior to intervention and 76% after while the control group's knowledge scores decreased by 1% (Abood, Black, and Birnbaum, 2004). Athletes who received nutrition education and improved their knowledge felt more confident. It empowered them to fuel their bodies, which is notable compared to other studies where athletes felt ill-equipped when making dietary choices without nutrition education. Therefore, it is not unreasonable to assume athletes at higher competition levels will have better nutrition knowledge and better dietary intake. Yet few studies have examined nutrition knowledge and dietary intake across different levels of competition, although knowledge scores tend to be higher in more elite athletes (Harrison, Hopkins, MacFarlane, and Worsley, 1991). Due to the broader conversation of additional factors besides nutrition knowledge influencing behavior, competition level should also be evaluated for its impact. Competition level not only influences the resources available to the athlete but also may affect their motivation and, in turn, dietary choices and behavior.

Although, one systematic review of the association between nutrition knowledge in athletes and their dietary intake found that the relationship is "equivocal," and there is a definite need for further investigation into this relationship (Heaney et al., 2011). It is important to evaluate the relationship at all levels of competition to examine what extent nutrition knowledge impacts dietary intake versus other factors such as motivation and nutrition resources available. Information on the relationship between nutrition knowledge and dietary intake will help to provide effective nutrition education and resources for athletes. The beneficial impact of nutrition on athletic performance is certain, and the implementation of performance nutrition strategies is necessary for peak performance. Further, female athletes are of particular importance due to their increased risk of having nutritional deficiencies, which can have long term negative implications for health. In conclusion, investigations into the interaction of nutrition knowledge and dietary intake are necessary for the future implementation of nutrition strategies to optimize performance at all competition levels.

CHAPTER 2

INTRODUCTION

Optimal dietary intake can support peak athletic performance, recovery from training, and general health and well-being (Thomas et al., 2016). Yet, further inspection into athlete's diets often reveals inadequate dietary practices to match the training demands of collegiate athletes (Abbey, Wright, and Kirkpatrick, 2017; Burke, Cox, Culmmings, and Desbrow, 2001; Rosenbloom, Jonnalagadda, and Skinner, 2002). Nutrition knowledge is one aspect that may impact dietary behavior, but this relationship has only slightly been explored (Heaney et al., 2011). With effective strategies to assess nutrition knowledge and dietary behaviors, practitioners would be able to assist athletes better and develop individualized and effective interventions.

Previous studies evaluating the diet of collegiate athletes, especially in females, often conclude that participants intake is below recommendations or that energy intake does not match physical activity demands (Brown et al., 2020; Jonnalagadda, Ziegler, and Nelson, 2004; Shriver, Betts, and Wollenberg, 2013). At the same time, correlations with diet and sports performance have been found. One study in elite female swimmers found a significant relationship between participants' 400 meter time trial velocity and energy intake ($r = .82$, $p=0.003$) and energy availability ($r = .64$, $p=0.04$) (Vanheest, Rodgers, Mahoney, and De Souza, 2014). Conventional methods for dietary assessment in these studies include 24 hour recalls, dietary records, and food frequency questionnaires (FFQ). Each method has been validated for various populations; however, they are not appropriate for all situations due to constraints such as finances or time.

One method previously used and validated for evaluating dietary intake in NCAA athletes is the REAP questionnaire. The REAP questionnaire was initially developed by the Nutrition Academic Award to help health care providers quickly assess patients' nutrition (Gans et al., 2003). The questionnaire allows practitioners to quickly assess a person's intake and consider whether or not they should be referred to a dietitian. More recently, REAP has previously shown to have good construct validity with NCAA DI athletes (Kurka et al., 2014). The REAP contains n= 31 items regarding food-frequency of meals (n= 2), grains (n= 1), fruits and vegetables (n= 2), dairy (n= 3), meats (n =5), fried foods (n= 1), snacks (n= 1), fats and oils (n= 3), sweets (n= 3), soft drinks (n= 1), sodium (n= 2), alcohol (n= 1), activity (n=1), and cooking behaviors (n= 3) per week along with attitudes toward behavior change (n= 1). The REAP is able to be administered in approximately ten minutes which allows for a quick and easy insight into a person's diet without being overly burdensome to administer and interpret.

Nutrition knowledge, in theory, may translate into better dietary behaviors, but nutrition knowledge of female collegiate athletes is not always sufficient. One study looking at track athletes from two NCAA DI universities found the average knowledge score was 58% ±13% with a range from 26%-76% (Rash, Malinauskas, Duffrin, Barber-Heidal, and Overton, 2008). Another systematic review of male and female athletes determined athletes have slightly higher knowledge than non-athletes. Still, the association between knowledge and dietary intake is weak and there is a need for research using validated tools to measure nutrition knowledge and its impact on dietary intake (Heaney et al., 2011).

The assessment of nutrition knowledge can be done through the recently developed Nutrition for Sport Knowledge Questionnaire (NSKQ). The NSKQ knowledge has been created for practitioners to assist in the development and evaluation of nutrition education programs (Trakman, Forsyth, Hoye, and Belski, 2017). The questionnaire addresses subcategories related to general knowledge as well as sport nutrition questions. The questionnaire has been shown to have good test-retest reliability and is also useful in research to better measure knowledge and evaluate interactions of knowledge with dietary choices.

The objective of this investigation was to evaluate the relationship between nutrition knowledge and reported dietary intake among female athletes at the NCAA DI, NJCAA, and Club sport levels. This will result in insight into the interaction of nutrition knowledge and dietary behaviors but also help guide practitioners to develop programs for effective changes in dietary choices.

Hypotheses:

- Female athletes in Phoenix, AZ, with higher nutrition knowledge, regardless of competition level, will have better reported dietary intake scores than female athletes with less nutrition knowledge.
- Female athletes in Phoenix, AZ at the NCAA DI competition level will have better nutrition knowledge and reported dietary intake compared to female athletes in Phoenix, AZ at the NJCAA and Club sport competition levels.

CHAPTER 3

METHODS

Participants

This secondary analysis involved participants from the Female Athlete Nutrition (FAN) Study conducted in 2019. Participants were female athletes (≥18 years old) competing in registered sports at the NCAA DI, NJCAA, and Club levels. The Female Athlete Nutrition (FAN) Study received ASU IRB approval (STUDY00009976) and complied with obtaining informed consent before study involvement.

Research Design

The cross-sectional FAN Study entailed one 45-minute visit to the Athl*ea*t Field Lab at Sun Devil Stadium, Tempe, AZ, or athletic training room at Mesa Community College, Mesa, AZ. Participants' height, weight, body max index (BMI), resting blood pressure, and fasting lipid and glucose levels (optional) were collected before four questionnaires; personal demographics, nutrition knowledge, dietary intake, and quality of life via the web- based platform (Qualtrics).

Only results from the Nutrition for Sport Knowledge Questionnaire (NSKQ) and Rapid Eating Assessment for Patients (REAP) obtained by the Female Athlete Nutrition Study were used for this secondary analysis.

Instruments

Nutrition for Sport Knowledge Questionnaire. The following NSKQ subscales were weight-management (n= 13), macronutrients (n= 30), micronutrients (n= 13), and alcohol (n= 8). The subscales can be scored separately or tallied for a total knowledge score. The subscales can be scored separately or tallied for a total knowledge score. The internal reliability (Kuder-Richardson-20+) for each subscale is reported as the following: weight-management 0.51, macronutrients 0.70, micronutrients 0.69, and alcohol 0.59. The test-retest reliability was found for weight-management r=0.0.81, macronutrients r= 0.0.81, micronutrients r= 0.76, and alcohol r= 0.66 using the Pearson's correlation formula. A Cronbach's alpha was calculated for this study and determined the total knowledge score to be 0.85, which is reasonable to accept as good internal consistency. A Cronbach's alpha for each subcategory was determined to be weight-management 0.51, macronutrients 0.70, micronutrients 0.69, and alcohol 0.59. Item deletion of each subscale was examined and deemed not to increase the reliability of the subscales (Trakman et al., 2017).

Based on the outcomes of the initial NSKQ questionnaire, the questionnaire was post-hoc modified to explore if a modified version would produce different outcomes. A modified NSKQ was scored as a secondary analysis with inclusion of only questions that were application-based and relevant to the majority of athletes. Upon reviewing the NSKQ, it was thought that some questions potentially included information beyond the knowledge level or irrelevant to the population studied here. For example, discussing the role of micronutrients requires knowledge of physiology and therefore extends beyond basic application knowledge expected of many collegiate athletes. The internal reliability of these modifications was reported as part of the results. See Appendix A for rationale on what questions were included and excluded.

Rapid Eating Assessment for Patients. The REAP questions are formatted as frequency categories of usually/often, sometimes, rarely/never, or does not apply to me. According to scoring recommendations, answering five or more times in the "usually/often" category should trigger a physician to consider referring the individual to a dietitian. The frequency of these "usually/often" answers were also tallied for an overall frequency score for analysis. For additional sport level comparisons, the answers were coded as usually/often = 1, sometimes = 2, rarely/never = 3, and does not apply to me/blank answers as missing. The questions are phrased, so "2" or "3" answers indicate healthier eating behaviors. The summed scores of the 25 items estimate diet quality, with higher scores indicating better quality (score range, 27-75) (Gans et al., 2006).

Statistical Analysis

For statistical analyses, SPSS version 25 was used. Data were not normally distributed; thus, outcomes are presented as the median and interquartile range (IQR), with the exception of demographic information in Table 2 which is presented as mean ± SD. The primary variables were nutritional knowledge and dietary intake. The nutrition knowledge scores were on a scale of 0-64 with sub-scores related to weight management, macronutrients, micronutrients, and alcohol. Dietary intake outcomes were expressed as frequency categories, including usually/often, sometimes, rarely/never, or does not apply to me. Kruskal- Wallis tests examined sport-level differences in knowledge scores and dietary intake outcomes with Mann-Whitney U tests. Chi-squares were performed to examine proportional sport-level differences in knowledge and types/categories of consumption of foods/drink items, with Cramer's V given as effect sizes for significant findings. Participants were divided into tertiles based on the IQR of knowledge categories to examine differences in behavior between high and low knowledge with Chi-squares. Spearman's correlation tests were performed to determine relationships of nutrition knowledge and dietary intake between sport levels and knowledge categories. All significance levels were set at $p < 0.05$.

CHAPTER 4

RESULTS

A total of N=120 female athletes (NCAA DI, n=51; NJCAA, n=32; Club, n=37) participated in the FAN study. Five participants were excluded due to incomplete questionnaires. Group sizes for sport levels were not significantly different, p= 0.21. Differences in age between sport levels were significantly different (H(2)= 24.03, p<0.001), yet, age did not correlate with total knowledge scores (r_s(118)= .15, p=0.11) or weight management (r_s(118)= .09, p=0.31), macronutrient (r_s(118)= .13, p=0.15), and micronutrient knowledge scores (r_s(118)= .06, p=0.49). However, age was significantly correlated with the alcohol knowledge subcategory on a total group level (r_s(118)= .20, p=0.03) possibly due to more exposure to alcohol meaning those who were older were more knowledgeable about alcohol. This correlation did not persist within the sport levels which suggests it is simply age that is weakly associated with alcohol knowledge. The majority of athletes in this study participated in soccer (17%), softball (12%), or track and field (20%), although there was a wide variety of sports that made up the entire sample. There were also differences between sport levels for training hours (p<0.05). Participant's demographic information can be seen in Table 2.

Table 2

Athlete Personal Demographics for All Athletes and per Sport Level

Demographics	All (N= 120)	NCAA DI (n= 51)	NJCAA (n= 32)	Club (n= 37)
		mean±SD		
Age	19.6±1.3	19.7±1.3	18.7±0.8*[a]	20.1±1.2
Height (cm)	166.5±6.6	169.3±6.3	164.6±6.3	164.4±6.2
Weight (kg)	65.5±11.7	64.6±9.3	65.8±11.0	66.4±15.1
Training hours per week	14.6±7.6	15.0±6.1	17.2±8.6	11.3±6.9*[b]
Sport years (playing current sport)	8.7±4.9	10.6±3.7	9.6±4.1	5.3±5.2

Note. Responses differed significantly between sport levels (*$p \leq 0.05$)

[a]indicates significant differences between NJCAA and athletes at NCAA DI and Club levels following post-hoc analysis.

[b]indicates significant differences between Club and athletes at NCAA DI and NJCAA levels following post-hoc analysis.

Nutrition Knowledge General Results

The median result on total nutrition knowledge scores overall was 52% (45 to 61). For NCAA DI, NJCAA, and Club sport levels individually, results were 55% (48 to 63), 45% (30 to 52), and 53% (45 to 63), respectively. Knowledge scores were significantly different between sport levels, $H(2)= 16.94$, $p< 0.001$. NCAA DI ($p<0.001$) and Club ($p<0.001$) athletes had higher nutrition knowledge than athletes at the NJCAA level (see Figure 1).

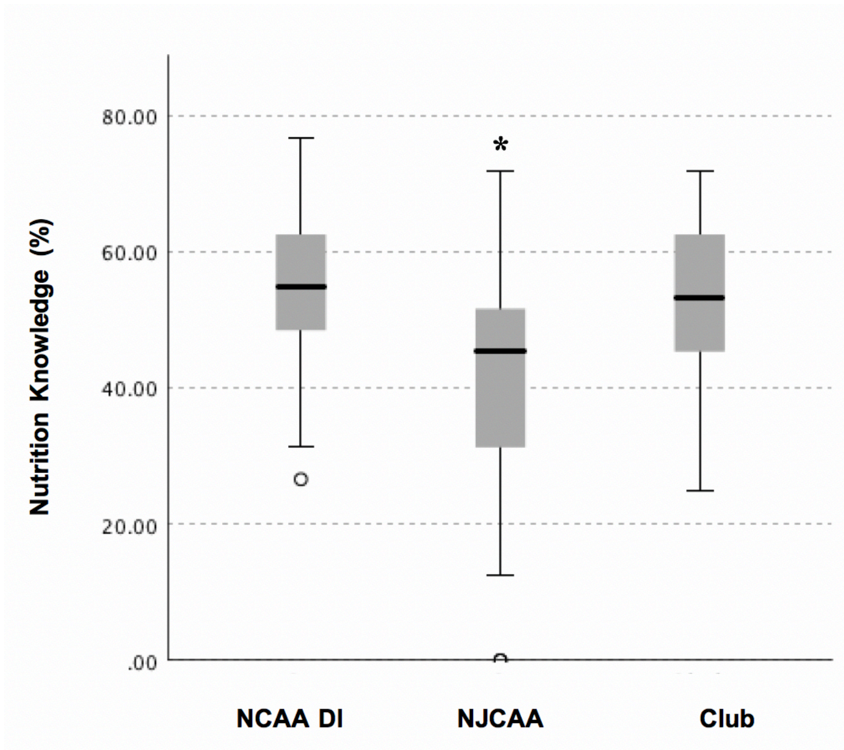

Figure 1. Nutrition knowledge scores per athlete level. *$p<0.05$.

Knowledge scores related to the subcategories were also significantly different between sport levels: weight management, H(2)= 9.58, p=0.006, macronutrients, H(2)= 8.51, p=0.008, micronutrients, H(2)= 9.58, p=0.014, and alcohol H(2)= 30.45, p<0.001. Weight management knowledge scores were higher in NCAA DI athletes than NJCAA and Club athletes (p=0.004). NCAA DI (p=0.01) and Club (p=0.04) athletes had higher nutrition knowledge related to macronutrients than athletes at the NJCAA level. NCAA DI (p=0.03) and Club (p=0.03) athletes had higher micronutrient nutrition knowledge than athletes at the NJCAA level. Alcohol nutrition knowledge was also higher in NCAA DI (p<0.001) and Club (p<0.001) than NJCAA athletes. (See table 3).

Table 3

Median and (IQR) Scores on NSKQ Expressed as Percentages for All Athletes and per Sport Level

Nutrition Knowledge Category	All (N= 120)	NCAA DI (n= 51)	NJCAA (n= 32)	Club (n= 37)
Total	52 (45 to 61)	55 (48 to 63)	45 (30 to 52)*[a]	53 (45 to 63)
Weight Management	54 (40 to 62)	54 (46 to 69)	46 (31 to 54)*[b]	54 (38 to 69)
Macronutrient	50 (43 to 57)	50 (43 to 63)	43 (31 to 50)*[a]	50 (43 to 60)
Micronutrient	46 (31 to 54)	46 (31 to 62)	31 (17 to 52)*[a]	46 (38 to 54)
Alcohol	75 (50 to 75)	75 (63 to 88)	50 (28 to 63)*[a]	75 (63 to 75)

Note. Medians differed significantly between sport levels (*$p \leq 0.05$).

[a]indicates significant differences between NJCAA and athletes at DI and Club levels following post-hoc analysis.

[b]indicates significant differences between NJCAA and NCAA DI levels following post-hoc analysis.

Dietary Intake General Results

The median diet quality score overall was 57 (52 to 61) and were 57 (52 to 62) for NCAA DI, 54 (46 to 60) for NJCAA, and 58 (55 to 62) for Club. No sport level differences in diet quality were found, H(2)= 5.77, p=0.06. Based on the REAP outcomes, 57% of athletes would be recommended to see a dietitian. Seventy-five percent of NJCAA athletes were recommended to see a dietitian compared to 50% of NCAA DI and Club athletes, $\chi 2(2)= 6.02$, p= 0.05, V= 0.22.

Table 4 outlines the median REAP scores for food categories. The score for each food category was calculated by averaging questions contained within the category.

Analysis of food categories revealed NJCAA scored more negatively related to meals, $\chi2$ (2)= 18.57, *p*= 0.02, V= 0.27, meats, $\chi2$ (2)= 44.30, *p*= 0.003, V= 0.43, fried foods, $\chi2$ (2)= 31.09, *p*<0.001, V= 0.36, sweets, $\chi2$ (2)= 40.52, *p*= 0.02, V= 0.40, and alcohol, $\chi2$ (2)= 28.89, *p*<0.001, V= 0.39 (see Table 4). Another notable observation was that seven NJCAA athletes reported consuming more than 1-2 alcoholic beverages in a single day "usually/often." At the same time, none did at the NCAA DI and Club sport levels.

Table 4

Median and (IQR) Scores on REAP Food Categories for All Athletes and per Sport Level

Food Category	All (N= 120)	NCAA DI (n= 51)	NJCAA (n= 32)	Club (n= 37)
	Median (IQR)			
Meal Intake	2.5 (2 to 3)	2.5 (2 to 3)	2 (1.8 to 2.8)**[a]	2.5 (2 to 3)
Grains	2 (2 to 3)	2 (2 to 3)	2 (2 to 3)	2 (1.5 to 3)
Fruits & Vegetables	2 (2 to 2.5)	2.5 (2 to 3)	2 (2 to 2.5)	2 (2 to 2.5)
Dairy	1.7 (1.3 to 2.3)	1.7 (1.3 to 2.3)	1.7 (1.3 to 2.3)	1.8 (1.7 to 2.3)
Meats	2.2 (1.8 to 2.4)	2 (1.8 to 2.4)	2 (1 to 3)	3 (2 to 3)**[c]
Fried Foods	3 (2 to 3)	3 (2 to 3)	2 (1 to 3)*[a]	3 (2 to 3)
Fats and Oils	2 (1.5 to 2.3)	1.9 (1.5 to 2.3)	2 (1.2 to 2.5)	2 (1.8 to 2.5)
Sweets	2.5 (2.3 to 2.8)	2.5 (2.3 to 2.8)	2.3 (1.9 to 2.8)*[a]	2.5 (2.3 to 2.8)
Sodium	2 (2 to 2.5)	2 (2 to 2.5)	2 (1.5 to 2.5)	2 (2 to 2.5)
Alcohol	3 (3 to 3)	3 (3 to 3)	3 (2.3 to 3)*[b]	3 (2 to 3)

Note. Responses differed significantly between sport levels (**p*≤0.05 or ** *p*≤0.001)

[a]indicates significant differences between NJCAA and athletes at NCAA DI and Club levels following post-hoc analysis.

[b]indicates significant differences between NJCAA and NCAA DI levels following post-hoc analysis.

[c]indicates significant differences between Club and athletes at NCAA DI and NJCAA levels following post-hoc analysis.

Table 5 identifies the percentage of athletes answering “usually/often” to the statements included, indicating negative dietary habits according to REAP scoring. Within parenthesis the “n” indicates the number of athletes responding to that particular statement. This data reveals during an average week, NJCAA athletes were more likely to consume processed meats over low-fat processed meats, $\chi2$ (2)= 13.47, p= 0.008, V= 0.25, fried foods $\chi2$ (2)= 21.31, p< 0.001, V= 0.30, chips over another low-fat snack option, $\chi2$ (2)= 9.37, p= 0.05, V= 0.20, sweets 2+ times per day, $\chi2$ (2)= 18.02, p= 0.001, V= 0.28, and drink more than 1-2 alcoholic drinks per day, $\chi2$ (2)= 14.01, p= 0.007, V= 0.28

Table 5

Frequency Count and Percentage of Athletes' Responses on REAP Questionnaire per Sport Level

Dietary Intake	NCAA DI (n= 51)			NJCAA (n= 32)			Club (n= 37)		
	Usually/ Often	Sometimes	Rarely/ Never	Usually/ Often	Sometimes	Rarely/ Never	Usually/ Often	Sometimes	Rarely/ Never
					% (n)				
Skip breakfast (n=120)	10 (5)	28 (14)	63 (32)	25 (8)	34 (11)	41 (13)	24 (9)	35 (13)	13 (15)
Eat takeout/restaurant meal 4$^+$ times per week (n=120)	10 (5)	24 (12)	67 (34)	22 (7)	31 (10)	47 (15)	5 (2)	19 (7)	76 (28)
Eat less than 3 servings of whole grains per day (n=117)	14 (7)	48 (24)	38 (19)	23 (7)	40 (12)	37 (11)	24 (9)	141 (15)	35 (13)
Eat less than 2-3 servings of fruit per day (n=118)	14 (7)	37 (19)	49 (25)	13 (4)	53 (16)	33 (10)	19 (7)	54 (20)	27 (10)
Eat less than 3-4 servings of vegetables per day (n=118)	12 (6)	45 (23)	43 (22)	17 (5)	47 (14)	37 (11)	14 (5)	51 (19)	35 (13)
Eat less than 2-3 servings of dairy per day (n=111)	32 (15)	38 (18)	30 (14)	27 (8)	47 (14)	27 (8)	38 (13)	38 (13)	24 (8)
Use 2% or whole milk over 1% or fat-free (n=95)	46 (19)	15 (6)	39 (16)	52 (14)	22 (6)	26 (7)	37 (10)	7 (2)	56 (15)
Use regular cheese over low-fat or Skim (n=107)	57 (27)	32 (15)	11 (5)	55 (16)	24 (7)	21 (6)	58 (18)	29 (9)	13 (4)
Eat beef, pork, or dark meat chicken 2$^+$ times per week (n=113)	54 (26)	29 (14)	17 (8)	45 (14)	39 (12)	16 (5)	32 (11)	29 (10)	38 (13)
Eat more than 6 oz of meat, chicken, or fish per day (n=113)	44 (21)	40 (19)	17 (8)	36 (11)	55 (17)	10 (3)	24 (8)*[c]	44 (15)*[c]	32 (11)*[c]
Choose higher fat red meats over lean red meats (n=110)	11 (5)	46 (21)	45 (21)	19 (6)	29 (9)	52 (16)	16 (5)	28 (9)	56 (18)
Eat skin on chicken/turkey or meat Fat (n=110)	28 (13)	30 (14)	43 (20)	23 (7)	39 (12)	39 (12)	22 (7)	19 (6)	59 (19)
Eat regular processes meats over low fat processed meats (n=111)	6 (3)	45 (21)	49 (23)	23 (7)*[b]	23 (7)*[b]	55 (17)*[b]	3 (1)	24 (8)	73 (24)
Eat fried foods (n=116)	4 (2)	37 (18)	59 (29)	32 (10)**[a]	39 (12)**[a]	29 (9)**[a]	3 (1)	36 (13)	61 (22)
Eat regular chips over low-fat chips/crackers, air popcorn, and pretzels (n=117)	20 (10)	43 (21)	37 (18)	52 (16)*[a]	26 (8)*[a]	23 (7)*[a]	22 (8)	38 (14)	41 (15)

Use regular dressings over low-fat or fat-free (n=110)	43 (21)	25 (12)	33 (16)	41 (12)	24 (7)	35 (10)	22 (7)	28 (9)	50 (16)
Add butter, margarine, or oil to foods at the table (n= 115)	30 (15)	46 (23)	24 (12)	37 (11)	30 (9)	33 (10)	31 (11)	49 (17)	20 (7)
Cook with oil, butter, or margarine over non-stick fat-free sprays (n=115)	53 (25)	28 (13)	19 (9)	42 (13)	29 (9)	29 (9)	49 (18)	27 (10)	24 (9)
Eat regular sweets over low-fat and fat-free sweets (n=118)	12 (6)	48 (14)	40 (20)	32 (10)	42 (13)	26 (8)	14 (5)	51 (19)	35 (13)
Eat regular ice cream over fat-free ice creams, yogurts, and sherbet (n=113)	27 (13)	41 (20)	33 (16)	33 (10)	40 (12)	27 (8)	18 (6)	41 (14)	41 (14)
Eat sweets 2^+ times per day (n=116)	4 (2)	14 (7)	82 (40)	26 (8)**[a]	26 (8)**[a]	48 (15)**[a]	3 (1)	17 (6)	81 (29)
Drink 16 oz of non-diet soda, fruit drink, or Kool-Aid per day (n=113)	6 (3)	9 (4)	85 (40)	10 (3)	30 (9)	60 (18)	8 (3)	14 (5)	78 (28)
Eat high sodium processed foods (n=118)	6 (3)	36 (18)	58 (29)	19 (6)	42 (13)	39 (12)	11 (4)	22 (8)	68 (25)
Add salt to foods at table or during Cooking (n=118)	38 (19)	34 (17)	28 (14)	32 (10)	29 (9)	39 (12)	51 (19)	19 (7)	30 (11)
Drink more than 1-2 alcoholic drinks per day (n= 89)*	0 (0)	8 (3)	92 (35)	11 (2)*[b]	16 (3)*[b]	74 (14)*[b]	0 (0)	31 (10)	69 (22)

Note. Next to each statement, "n" is the number of responses to that particular statement. The frequency (n) and percentage data are presented as % (n).

Responses differed significantly between sport levels (*$p \leq 0.05$ or ** $p \leq 0.001$).

[a]indicates significant differences between NJCAA and athletes at NCAA DI and Club levels following post-hoc analysis.

[b]indicates significant differences between NJCAA and NCAA DI levels following post-hoc analysis.

[c]indicates significant differences between Club and NCAA DI levels following post-hoc analysis.

Relationships Between Nutrition Knowledge and Dietary Intake within Subgroups

Competition Level.

There was no correlation between nutrition knowledge and diet quality scores ($r_s(118) = .11$, $p = 0.22$). A significant weak correlation was found between alcohol knowledge and "usually/often" responses ($r_s(118) = .19$, $p = 0.03$). Relationships within competition levels were also examined. This revealed that the overall relationship between alcohol knowledge and "usually/often" responses is primarily driven by the correlation within the NCAA DI competition group ($r_s(49) = .30$, $p = 0.03$). No other significant relationships were found (See Table 6).

Table 6

Spearman Correlation and 95% CI for Knowledge Scores against Dietary Intake for All Athletes and per Sport Level

Nutrition Knowledge Category	All (N= 120)	NCAA DI (n= 51)	NJCAA (n= 32)	Club (n= 37)
Total & "Usually/often" Frequency	-0.10 (-0.28 to 0.08)	0.10 (-0.18 to 0.37)	0.12 (-0.24 to 0.45)	-0.26 (-0.54 to 0.07)
Weight Management & "Usually/often" Frequency	-0.09 (-0.26 to 0.09)	0.04 (-0.24 to 0.31)	0.12 (-0.24 to 0.45)	-0.30 (-0.56 to 0.04)
Macronutrient & "Usually/often" Frequency	-0.07 (-0.25 to 0.11)	0.15 (-0.13 to 0.41)	0.11 (-0.24 to 0.45)	-0.28 (-0.55 to 0.05)
Micronutrient & "Usually/often" Frequency	0.02 (-0.16 to 0.20)	0.09 (-0.19 to 0.36)	0.22 (-0.25 to 0.44)	-0.07 (-0.39 to 0.26)
Alcohol & "Usually/often" Frequency	-0.19 (-0.36 to -0.02)*	-0.30 (-0.53 to -0.03)*	0.12 (-0.14 to 0.53)	-0.05 (-0.37 to 0.28)

Significance was set at $*p<0.05$.

Dietitian Referral Categories. Participants were divided into "low" =0-4 "medium" =5-10, and "high" =11+ categories based on usually/often frequencies. It was determined there were no differences between sport levels, $\chi 2$ (2)= 8.17, p= 0.09 for "usually/often" frequency categories. There was a significant association between "usually/often" frequency categories and macronutrient knowledge, $\chi 2$ (2)= 69.49, p= 0.02, V= 0.50. No other significant relationships were found (See Table 7).

Table 7

Median and (IQR) Scores on NSKQ expressed as percentages between Low, Medium, or High "Usually/Often" Frequency Categories

	"Usually/often" Frequency		
	Low (n=51)	Medium (n= 50)	High (n=19)
Nutrition Knowledge Category			
Total	53 (47 to 63)	50 (40 to 61)	47 (38 to 59)
Weight Management	54 (46 to 69)	54 (38 to 62)	46 (31 to 62)
Macronutrient	50 (43 to 63)	47 (40 to 57)*[a]	50 (37 to 53)
Micronutrient	46 (31 to 54)	46 (29 to 62)	38 (31 to 54)
Alcohol	75 (63 to 75)	69 (50 to 75)	50 (50 to 75)

Note. Scores differed significantly between "usually/often" frequency categories (*$p \leq 0.05$).

[a]indicates significant differences between Medium and athletes within the Low and High "usually/often" frequency categories.

Knowledge Categories. Participants were also divided into groups of low, average, and high knowledge based on quartiles of the distribution. It was determined there were significant differences between sport levels, $\chi2$ (2)= 13.72, *p*= 0.01, V=0.24, for knowledge categories. The high nutrition knowledge group scored better on the REAP questionnaire, except the sodium category. This is consistent with data displaying a more positive intake in NCAA athletes compared to NJCAA as NCAA athletes comprise most of the high knowledge category. The high knowledge group scored highest on the fruit and vegetable, meats, and fried foods categories. The high nutrition knowledge group had an average REAP score of 2.32 versus the low and average knowledge groups of 2.16 and 2.15, respectively. Differences in behavior between low and high knowledge levels were significant in the meal intake, $\chi2$ (2)= 11.80, *p*= 0.002, V= 0.45, fruits and vegetables, $\chi2$ (2)= 10.01, *p*= 0.01, V= 0.42, fried foods, $\chi2$ (2)= 14.36, *p*= 0.001, V= 0.51, sweets, $\chi2$ (2)= 11.76, *p*= 0.01, V= 0.45, and alcohol categories, $\chi2$ (2)= 6.40, *p*= 0.02, V= 0.39 (See Table 8).

Table 8

Median and (IQR) Scores on REAP Food Categories Between Low, Average, or High Knowledge Categories

	Knowledge Category		
	Low (n=29)	Average (n= 66)	High (n= 30)
Food Category			
		Median (IQR)	
Meal Intake	2 (1.5 to 2.8)*[a]	2.5 (2 to 3)	2.5 (2.4 to 3)
Grains	2 (1 to 3)	2 (1.5 to 3)	2 (2 to 3)
Fruits and Vegetables	2 (1.5 to 2.5)*[a]	2 (1.9 to 2.5)	2.5 (2 to 3)
Dairy	2 (1.3 to 2.2)	1.7 (1.3 to 2)	1.7 (1.3 to 2.6)
Meats	2 (1.8 to 2.4)	2 (1.6 to 2.4)	2.4 (2 to 2.6)
Fried Foods	2 (1.8 to 3)*[a]	2 (2 to 3)	3 (2.8 to 3)
Fats and Oils	2 (1.3 to 2.3)	2 (1.5 to 2.4)	2 (1.5 to 2.5)
Sweets	2.3 (1.7 to 2.8)*[a]	2 (1.5 to 2.4)	2 (1.5 to 2.5)
Sodium	2.5 (1.6 to 2.9)	2 (1.5 to 2.5)	2 (2 to 2.5)
Alcohol	3 (2 to 3)*[a]	3 (2 to 3)	3 (3 to 3)

Note. Responses differed significantly between Knowledge Categories (*$p \leq 0.05$).

[a]indicates significant differences between Low and High knowledge categories following post-hoc analysis.

Spearman's correlations were conducted to determine any existing relationships between nutrition knowledge and dietary intake within knowledge category groups. Overall, the only significant relationship based on this data was the correlation between micronutrient knowledge and dietary behavior ($r_s(28)= .61$, $p<0.001$). An interesting observation is there is a sharp cut off in micronutrient knowledge <53.85% in which those who score below this value also tend to score more negatively on the REAP questionnaire as well. No other significant relationships were found (See Table 9).

Table 9

Spearman Correlation Values and 95% CI of Knowledge Scores against Dietary Intake Between Groups with Low, Average, or High Knowledge Categories

	Knowledge Category		
	Low (n=29)	Average (n=66)	High (n=30)
Nutrition Knowledge Category			
Total	0.03 (-0.34 to 0.40)	0.12 (-0.12 to 0.35)	-0.26 (-0.57 to 0.11)
Weight Management	0.03 (-0.34 to 0.40)	0.05 (-0.20 to 0.28)	0.09 (-0.28 to 0.44)
Macronutrient	0.23 (-0.15 to 0.55)	0.07 (-0.17 to 0.31)	-0.05 (-0.40 to 0.32)
Micronutrient	0.61 (0.31 to 0.80)*	0.14 (-0.10 to 0.37)	0.05 (-0.32 to 0.40)
Alcohol	0.09 (-0.29 to 0.44)	-0.18 (-0.41 to 0.06)	-0.10 (-0.44 to 0.27)

Note. The low and high categories were comprised of the lower and upper quartiles for knowledge scores while the average category contained those within 25%-75% of the distribution.

Significance was set at *$p<0.001$.

Modified Knowledge Questionnaire

A modified NSKQ questionnaire (n=36) was created to determine if more basic and application-based questions would reveal higher correlations with dietary behavior (See Appendix A). The median result on total modified nutrition knowledge scores overall was 54% (48 to 62). For NCAA DI, NJCAA, and Club sport levels individually results were 58% (50 to 64), 46% (35 to 55), and 54% (48 to 65), respectively. The

Spearman's correlation value for the modified NSKQ total score and dietary behavior, according to REAP, increased slightly but was still not significant ($r_s(118) = -.11$, $p = 0.22$). Item deletion of each subscale was examined and deemed not to increase the reliability of the subscales. It was determined the Cronbach's alpha value for this new questionnaire decreased to 0.73. Cronbach's alpha values for internal consistency of each subcategory were as follows: weight-management 0.30, macronutrients 0.55, micronutrients 0.49, and alcohol 0.41. Despite slight decreases in internal consistency values, knowledge scores and correlation values increased.

CHAPTER 5

DISCUSSION

There was no correlation between nutrition knowledge scores and dietary quality or dietitian referral on total group level or within competition levels. The median result on total nutrition knowledge scores overall was moderate at 52% with NJCAA athletes reporting significantly lower knowledge (45%) than NCAA DI (55%) and Club (53%) athletes. The median diet quality score was 57 points overall out of a possible 75. Despite no differences in diet quality score between sport levels, NJCAA athletes should be more often referred to a dietitian in comparison to the other sport levels. Modifying the NSKQ did not improve correlation with REAP outcomes while decreasing the internal consistency of the questionnaire.

The results of this study further reinforce the need for additional research determining the practicality of these tools assessing athletes' nutrition knowledge and dietary intake. Based on existing literature, it was expected that the correlations might not be very strong (Heaney et al., 2011), but should be detectable. It is interesting that while NJCAA participants consistently scored less favorably than NCAA DI and Club athletes, both in knowledge and dietary behavior, no clear relation between the two tools could be determined.

Nutrition Knowledge

Nutrition knowledge had no impact on whether athletes would be referred to a dietitian or not based on REAP scoring. Knowledge scores were significantly lower at the NJCAA level than NCAA DI and Club sports athletes, except for weight management in which there was no difference between Club and NJCAA athletes. An overall median score of 52%, as reported in this study, is generally consistent with previous literature (Abood, Black, and Birnbaum, 2004; Douglas and Douglas, 1984; Jonnalagadda et al., 2004). However, it is difficult to directly compare these outcomes to other studies, as nutrition knowledge assessment tools and their quality, or lack of, differs between studies (Trakman et al., 2016).

Dividing participants into knowledge categories based on the quartile ranges revealed worse diet quality in the low knowledge group compared to the high group. These findings are consistent with data comparing competition levels as NJCAA athletes comprise the majority of the low knowledge category and were previously shown to have lower diet quality.

The NSKQ was developed and validated in 2017 in Australian athletes (Trakman et al., 2017). We used the questionnaire to collect data for this study in 2019. Since the questionnaire's development, the creators have modified some questions and answer choices based on new evidence and feedback from colleagues (Trakman, Brown, Forsyth, and Belski, 2019). The latest modifications to the questionnaire demonstrate the ongoing evolution of tools used to assess nutrition knowledge in athletic populations. For the purposes of this study, the NSKQ was modified to reflect only the questions that asked athletes to apply knowledge or related to a basic nutrition concept. Despite our efforts based in practical knowledge and defining what we felt to be important knowledge for student-athletes, the internal consistency of the modified nutrition questionnaire developed in this analysis decreased and ultimately still failed to reveal a significant correlation with diet behavior. Although, it is still necessary to reflect on knowledge appropriate for the competition level being assessed. For example, it might be inappropriate to ask a power athlete about the carbohydrate needs of an endurance athlete (Tam, Beck, Gifford, Flood, & O'Connor, 2020).

Dietary Intake

Over half of the athlete participants would be recommended to see a dietitian. Seventy-five percent of NJCAA athletes would be recommended to see a dietitian compared to 50% of NCAA DI and Club athletes. NJCAA athletes also reported negative dietary behaviors most often ($p<0.05$). The overall median diet quality score overall was 57 out of a possible 75. At a group level diet quality did not differ significantly suggesting all participants should have opportunities for improvement in their dietary behaviors. Using the number of "usually/often" responses versus a total diet quality score resulted in different overviews of each sport level. When using "usually/often" responses, significantly more students would be referred to a dietitian at the NJCAA level but their total diet quality score suggests no significant difference compared to NCAA DI and Club. Although, NCAA DI and Club. Although, seven participants at the NJCAA level had a diet quality score <45 while there were three and one participants and the NCAA DI and Club levels, respectively. These differences demonstrate why it is necessary to have an experienced practitioner evaluate REAP outcomes for individuals and not an entire population. Five or more "usually/often" responses should lead to further investigation into a persons diet in which overall diet quality can be assessed. Further investigation may reveal differences in dietary behavior, as was shown, for example, with NJCAA athletes consuming fried foods and alcohol more frequently.

As discussed previously, the REAP questionnaire has been validated in NCAA populations (Kurka, Buman, and Ainsworth, 2014). This validation study revealed differences in dietary patterns between some types of athletes, while this study revealed differences between competition levels. Kurka and colleagues found female aesthetic athletes had more scored better than non-aesthetic athletes in the high-fat meats, fat, and dairy categories. In this study, NJCAA athletes reported higher intakes of high-fat meats, fried foods, sweets, alcohol, and poor meal habits ($p<0.05$). High-fat meats, fried foods, sweets, and alcohol are all calorie-dense foods and will often lead to unwanted weight gain when consumed in excess. Skipping breakfast, a component within the meal category, is also a high-risk behavior, particularly for students, as an overnight and morning fast have been shown to have adverse effects on cognition (Pollitt, 1995). One study by Cona and colleagues (2015) demonstrated that those who had superior cognitive performance were also faster runners. Both excess weight gain and impaired cognition may ultimately have effects on negative performance, further demonstrating the need for quality nutrition strategies in athletic populations (Thomas et al., 2016).

During one previous study, Robinson and colleagues (2015) determined "a meaningful interpretation of the overall REAP score was also difficult," leading them to include only fruit and vegetable portions of the questionnaire for some of their analysis. The same is true in collegiate athletic populations that interpretation and scoring of the REAP questionnaire should be critically analyzed. Athletes are advised to have individualized nutrition plans (Thomas et al., 2016). Therefore, some questions may be inappropriate and may not have poor diet quality despite scoring negatively on some REAP questions. For example, adding salt to foods at the table or during cooking may be contradictory to what an athlete with a high sweat sodium content might be told. It was thought to make comparisons between dietitian referral categories, or those who may be "more likely" to be referred to a dietitian based on the frequency of "usually/often" responses on REAP rather than using a cut off of five or more responses. However, dividing participants into categories based on the frequency of "usually/often" responses revealed no differences in nutrition knowledge between groups who may be increasingly likely to be referred to a dietitian.

Environment

It is interesting to note that NJCAA athletes scored more negatively in the REAP questionnaire while NCAA DI and Club athletes scored similarly, yet, they are all different competition levels. However, the NCAA DI and Club athletes came from the same, more expensive university, while the NJCAA participants were from a different, less expensive community college. A study in British Army Infantry recruits found no difference in eating patterns using the REAP questionnaire. However, the author acknowledged that all recruits had access to and were around similar foods (Robinson, 2015). There is the possibility in this scenario that the participants had access to different food environments in different cities that enabled different eating habits reflected on the REAP questionnaire outcomes. Previous observational studies have demonstrated associations between sugar intake and proximity to food retail facilities (Laska, Hearst, Forsyth, Pasch, and Lytle, 2010).

Demographics

Demographic information revealed NJCAA athletes were slightly younger compared to DI and Club athletes, although not significantly, which may explain some of the disparities as young adults are still learning eating behaviors away from home. On average, NJCAA athletes had been playing their current sport for almost twice as long as Club athletes, so it is more likely they would have had some exposure to nutrition-related to their sport than someone who has not been playing as long, but this cannot be confirmed. Additionally, it is expected NJCAA athletes would be younger as they come from an institution that only offers two-year programs versus four-year programs at the NCAA university. One study comparing two-year versus four-year university students (N=1687) also found students at the four-year university consumed better diets even after controlling for sociodemographic and living arrangements (Nelson, Larson, Barr-Anderson, Neumark-Sztainer, and Story, 2009). The authors concluded the differences might be due to "lifestyle factors" including food access, social support, and stress management.

Limitations

If the data had been collected more recently and pending validation, the updated version of the NSKQ would have been used, which may have changed athletes' responses. Due to the nature of some of the edits to the NSKQ, such as changing wording or answers on the multiple-choice questions, it is difficult to determine how results really would have changed based on this data alone. The REAP questionnaire to assess dietary quality also has some limitations. Contributors to REAP also acknowledged it may not be appropriate in research settings "because the precision of the estimates of some individual nutrients or food groups was low." There are limited response options to the questions (usually/often, sometimes, rarely/never, or N/A), which provides limited detail on eating patterns. Additionally, there are multiple ways to score the REAP questionnaire, frequency counts of “usually/often” responses and the total score (Gans et al., 2006). A final limitation is the absence of additional information on participants such as socioeconomic status, access to food resources, financial aid, and so on.

Conclusions

Based on outcomes of this study, there is no relationship between nutrition knowledge and dietary intake, regardless of competition level. No difference was found between sport levels for total diet quality scores, but NJCAA student-athletes scored more often to be referred to a dietitian. At the same time NJCAA student-athletes reported lower knowledge scores than Division I student-athletes and Club sport athletes at a college level. Improvements in the assessment of nutrition knowledge and quick assessment of dietary quality and the relation between both is needed.

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APPENDIX A

RATIONALE OF QUESTIONS INCLUDED IN THE MODIFIED KNOWLEDGE QUESTIONNAIRE

Question Number	Question	Included?	Rationale
Weight Management 1	Which nutrient do you think has the most energy (kilojoules/calories) per 100 grams (3.5 ounces)?	X	Application question to identify which macronutrient is the most energy dense
Weight Management 2.1	In endurance sports, having the lowest weight possible benefits performance in the long term		Question related to weight and performance but not necessarily nutrition
Weight Management 2.2	Increasing protein in the diet is the main dietary change needed when only muscle gain is desired		Question related to modification of body composition, somewhat open to interpretation using "main dietary change"
Weight Management 2.3	Protein eaten in excess of bodily needs can lead to fat gain		Question related to body composition
Weight Management 3.1	Increase Intake of Low-energy foods such as vegetables	X	Application question, gives specifics on what qualifies as "low energy foods"
Weight Management 3.2	Swap butter for canola spread		Canola spread may be an unfamiliar food to this population

	(polyunsaturated margarine)		
Weight Management 3.3	Exchange yogurts, muesli/granola bars and fruit snacks for protein bars and shakes	X	Application question, refers to foods often readily available to athletes
Weight Management 3.4	Choose lower glycemic index (GI) carbohydrates		Requires advanced nutrition knowledge, results also controversial related to weight loss
Weight Management 3.5	Stop eating carbohydrate-containing foods (e.g. rice and pasta) after 4 pm		Somewhat non-specific, open to interpretation if these foods are being replaced with other foods or not
Weight Management 4	When weight loss is desired, generally athletes should:	X	General knowledge question applicable for weight management
Weight Management 5	To ensure they meet their energy (kilojoule/calorie) requirements, all athletes should:	X	Basic nutrition knowledge question
Weight Management 6	Which do you think is the best lunch option for an athlete trying to gain weight (muscle)?	X	Application question to choose the appropriate meal for the situation

	Assume they are training in the morning and have already had breakfast and a mid-morning snack.		
Weight Management 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.	X	Application question to choose the appropriate meal for the situation
Macronutrients 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?		Not applicable or relevant to all athlete populations, inquires about g/kg recommendations which many athletes are likely unaware of
Macronutrients 2.1	Do you think these foods are high or low in carbohydrate? 1 Medium Banana	X	Application question identifying carbohydrate containing foods
Macronutrients 2.2	Do you think these foods are high or low in carbohydrate? ½ cup cooked Quinoa	X	Application question identifying carbohydrate containing foods
Macronutrients 2.3	Do you think these foods are high or low	X	Application question identifying carbohydrate containing foods

	in carbohydrate? 1 Tablespoon Butter		
Macronutrients 2.4	Do you think these foods are high or low in carbohydrate? 1 Cup Baked Beans	X	Application question identifying carbohydrate containing foods
Macronutrients 3	Which of the following foods do you think contains the most carbohydrate?	X	Application question to identify carbohydrate content
Macronutrients 4.1	Fat is required by the body to make cell membranes and molecules involved in immune function		Question related to structure of cells
Macronutrients 4.2	For athletes, no more than 20g of fat should be eaten per day		Requires advanced nutrition knowledge to quantify the amount of fat
Macronutrients 4.3	When exercise intensity increases, the relative amount (%) of fat that is burnt to supply body with fuel increases		Exercise physiology question related to fuel sources
Macronutrients 4.4	When exercising at low intensities,fat provides almost all the		Exercise physiology question related to fuel sources

	substrate needed to cover energy costs		
Macronutrients 5.1	Do you think these foods are high or low in fat? ½ Cup Cottage cheese	X	Application question identifying fat containing foods
Macronutrients 5.2	Do you think these foods are high or low in fat? 1 Tablespoon polyunsaturated margarine	X	Application question identifying fat containing foods
Macronutrients 5.3	Do you think these foods are high or low in fat? ¼ Cup Mixed nuts	X	Application question identifying fat containing foods
Macronutrients 5.4	Do you think these foods are high or low in fat? 1 Tablespoon Honey	X	Application question identifying fat containing foods
Macronutrients 6.1	Protein is the main source of energy used by muscles during exercise		Exercise physiology question related to fuel sources
Macronutrients 6.2	Vegetarian athletes can meet their protein requirements without		Not applicable to all athletes, special population question

	the use of protein supplements		
Macronutrients 6.3	A well-trained athlete needs more protein than a young athlete who is just beginning training		Not applicable to all athletes, special population question
Macronutrients 6.4	Protein absorption in a single sitting is limited		Physiology question related to mechanisms of digestion
Macronutrients 6.5	A balanced diet with adequate kilojoules/calories (energy) should meet all protein needs	X	Basic nutrition knowledge and application question
Macronutrients 7	Which of the following foods do you think contains the most protein?	X	Application question to identify protein content
Macronutrients 8	The protein needs of a 100 kg (220 lb) well trained resistance athlete are closest to:		Not applicable or relevant to all athlete populations
Macronutrients 9.1	Do you think these foods are high or low in protein? 100g (3	X	Application question identifying protein containing foods

	ounces) Chicken Breast		
Macronutrients 9.2	Do you think these foods are high or low in protein? 30g (1 ounce) Yellow Cheese	X	Application question identifying protein containing foods
Macronutrients 9.3	Do you think these foods are high or low in protein? 1 Cup Baked Baked Beans	X	Application question identifying protein containing foods
Macronutrients 9.4	Do you think these foods are high or low in protein? 1/2 Cup Cooked Quinoa	X	Application question identifying protein containing foods
Macronutrients 10	Do you think these foods contain all the essential amino acids needed by the body?		Requires advanced nutrition knowledge about essential amino acids
Macronutrients 11	The amount of protein in skim milk compared to full cream milk is:		Not an application question, inquires about food processing
Micronutrients 1.1	Calcium is the largest structural component of bone crystals		Physiology question about the role of micronutrients

Micronutrients 1.2	Vitamin C acts as an antioxidant in the body		Physiology question about the role of micronutrients
Micronutrients 1.3	Thiamine (Vitamin B1) is required for efficient delivery of oxygen to muscles		Physiology question about the role of micronutrients
Micronutrients 1.4	The main role of Iron is the conversion of food into usable energy		Physiology question about the role of micronutrients
Micronutrients 2.1	Meat, Chicken and Fish Are The best sources of zinc	X	Application question identifying micronutrient content of foods
Micronutrients 2.2	Whole grain foods are the best sources of vitamin C	X	Application question identifying micronutrient content of foods
Micronutrients 2.3	Fruit and Vegetables are the best sources of calcium	X	Application question identifying micronutrient content of foods
Micronutrients 2.4	Milk, Yogurt and Cheese are the best source of magnesium	X	Application question identifying micronutrient content of foods

Micronutrients 3.1	Athletes have increased magnesium needs due to losses in sweat		Exercise physiology question related to sweat content
Micronutrients 3.2	Women who are menstruating have higher iron needs than men	X	Basic nutrition knowledge application question related to iron needs
Micronutrients 3.3	The optimal calcium intake for athletes aged 15 to 24 years is 500 mg		Requires advanced nutrition knowledge to quantify the amount of calcium for a specific age group
Micronutrients 3.4	A physically fit person eating a nutritionally adequate diet can improve their performance by eating more vitamins and minerals		Hypothetical question open to other interpretations
Micronutrients 3.5	Vitamins provide the body with energy (kilojoules/calories)		Requires advanced nutrition knowledge and may be beyond an athlete's education
Alcohol 1	How many grams/ fluid ounces of ethanol (pure alcohol) does a standard drink generally contain?		Requires advanced nutrition knowledge about the weight of alcohol in a standard drink

Alcohol 2	Which of the following do you think is an example of a "Standard Drink"?	X	Application question identifying a single portion of a standard drink
Alcohol 3	When consumed as part of the diet, pure alcohol (ethanol) contains calories/kilojoules and, therefore, can lead to weight gain.	X	Application question relevant to much of the alcohol education provided to collegiate athletes
Alcohol 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:	X	Application question regarding maximum daily alcohol intake recommendations
Alcohol 5.1	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		Hypothetical question and unrelated to nutrition practices specifically
Alcohol 5.2	Drinking Large Amounts Of Alcohol Can Reduce Recovery from injury		Requires advanced nutrition knowledge related to a special population

Alcohol 5.3	Alcohol has been shown to increase urinary losses during post- exercise recovery	X	Application question related to hydration and relevant to much of the alcohol education provided to collegiate athletes
Alcohol 6	"Binge drinking" (also referred to as heavy episodic drinking) is generally defined as:		Non-application question and unrelated to nutrition practices specifically