Exploration of Sports Nutrition Knowledge, Nutrition Practices, and Physical Performance on Standardized U.S. Navy Physical Fitness Assessments in a ROTC Population

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ABSTRACT

Although physical fitness is regarded as a determinant of combat readiness, more than two-thirds of American military personnel are considered overweight or obese. While the U.S. Army recognizes nutrition as a priority with the development of the Performance Triad, nutrition education in the U.S. Navy remains retroactive, targeting only weight management and neglecting the role of nutrition in performance enhancement. There is limited data regarding the nutrition knowledge of the U.S. Navy population, a key factor in designing nutrition-focused programs, partially due to the lack of an appropriate assessment tool. The purpose of this study was two-fold: 1) validate an 86-item modified Nutrition for Sport Knowledge Questionnaire (M-NSKQ) using 15 Registered Dietitian Nutritionists (RDN) from across the country, and 2) assess sports nutrition knowledge, nutrition practices, and performance on physical fitness assessments (PFA) from a sample of 102 midshipmen in the Naval Reserve Officer Training Corps (NROTC) at Virginia Tech. The M-NSKQ assesses nutritional knowledge regarding weight management, macronutrients, micronutrients, hydration, nutrient timing, supplementation, and alcohol. The mean M-NSKQ score for RDNs was 84%, and questions with less than 50% correct responses were modified. Although no significant associations were found between M-NSKQ scores and PFAs for midshipmen, the mean M-NSKQ score was only 51%, and less than 10% met the daily recommendations for fruit, vegetables, grains, and dairy. Specific areas for improvement are discussed. These results highlight the need for nutrition education that is designed to address the gaps in knowledge and poor nutrition practices identified within this naval population.

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GENERAL AUDIENCE ABSTRACT

Although physical fitness is regarded as a determinant of combat readiness, more than two-thirds of American military personnel are considered overweight or obese. While the U.S. Army recognizes nutrition as a priority with the development of the Performance Triad, nutrition education in the U.S. Navy remains retroactive, targeting only weight management and neglecting the role of nutrition in performance enhancement. There is limited data regarding the nutrition knowledge of the U.S. Navy population, a key factor in designing nutrition-focused programs, partially due to the lack of an appropriate assessment tool. The purpose of this study was two-fold: 1) validate an 86-item modified Nutrition for Sport Knowledge Questionnaire (M- NSKQ) using 15 Registered Dietitian Nutritionists (RDN) from across the country, and 2) assess sports nutrition knowledge, nutrition practices, and performance on physical fitness assessments (PFA) from a sample of 102 midshipmen in the Naval Reserve Officer Training Corps (NROTC) at Virginia Tech. The M-NSKQ assesses nutritional knowledge regarding weight management, macronutrients, micronutrients, hydration, nutrient timing, supplementation, and alcohol. The mean M-NSKQ score for RDNs was 84%, and questions with less than 50% correct responses were modified. Although no significant associations were found between M-NSKQ scores and PFAs for midshipmen, the mean M-NSKQ score was only 51%, and less than 10% met the daily recommendations for fruit, vegetables, grains, and dairy. Specific areas for improvement are discussed. These results highlight the need for nutrition education that is designed to address the gaps in knowledge and poor nutrition practices identified within this naval population.

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Chapter 1: Review of Literature

Introduction

Only 35% of the United States (U.S.) Armed Forces are classified as "healthy weight", with 52% of the remainder considered overweight and 13% considered obese. [1] Although the prevalence of obesity in the military is much lower than 38% rate of obesity in the general civilian population [2], these statistics contradict the values of the military institution. The Department of Defense states that, "physical fitness is essential to combat readiness and is an important part of the general health and well-being for Armed Forces personnel". [3] Not only are military personnel expected to perform as athletes, they are expected to maintain a "military appearance" in the public eye and on the world stage.[3] This expectation is upheld separately by each military branch with branch-specific body composition and physical performance standards. Despite the well-established relationship between proper nutrition and physical performance [4], the emphasis on nutrition as a component of combat readiness varies drastically across military branches. The need for preventive nutrition education in the military was noted as early as 1995. [5] The U.S. Army introduced the Performance Triad Initiative in 2013, identifying sleep, activity, and nutrition as cornerstones to military performance. Yet in the U.S. Navy, nutrition education remains a retroactive measure, targeted at weight management, rather than performance enhancement. [6, 7] The lack of comparable initiatives in the Navy may be, in part, due to the limited data supporting the correlation between nutrition *knowledge* and physical performance, which is compounded further by the lack of an appropriate nutrition knowledge assessment tool for this population. [8, 9]

Study Population

The population of interest is the Naval Reserve Officer Training Corps (NROTC). This population will be studied using a convenience sample of cadets from the NROTC unit at Virginia Tech.

The Department of the Navy is separated into two organizational branches, administrative and operational. The operational sector differentiates the U.S. Navy from the U.S. Marine Corps, two independent military branches with separate physical fitness standards. The administrative sector encompasses medical, educational, and training functions for the entire Department of the Navy. This caveat in organizational structure means that any nutrition-related programming, including the services of commissioned Navy dietitians, serves both the Navy and Marine Corps. [10]

NROTC also falls under the joint administrative function of the Navy as a training program for college students pursuing leadership careers in the Navy or Marine Corps. ROTC cadets under Naval Command are specifically referred to as midshipmen. Midshipmen complete military training in addition to the normal academic requirements of their respective institution and receive scholarships contingent upon their agreement to serve upon graduation. [11]

ROTC midshipmen are not included in the Department of Defense Workforce Reports and are not to be confused with the U.S. Navy Reserve. NROTC provides the largest source of accession for Navy officers. [12] In total, the United States Navy employs 325, 802 active-duty sailors, including 54, 114 officers and 267, 286 enlisted sailors. Of the active duty Navy officers, 17.4% are female and 82.6% are male. Although the sex breakdown of enlisted sailors is nearly identical to that of officers, the officer population is notably less racially diverse. In comparison

to the enlisted population that is comprised of 42% minorities, only 21% of the officers are minorities. [13]

Additionally, there are currently 184,427 active duty marines, including 21,335 officers and 267,286 enlisted marines. While the Marine Corps has a similar minority population to the Navy at 19%, only 7% of marines are female.[1] The Navy ROTC population is expected to most closely resemble that of active-duty Navy officers. ROTC cadets, regardless of their military branch affiliation, represent a unique population as a whole in that they are a subset of both college and military populations.

The purpose of this literature review is to examine research related to Navy ROTC on nutrition knowledge, nutrition practices, and physical performance. However, few existing studies have addressed these topics within ROTC populations [14-17], one of which was focused on an Army ROTC population, while the others did not specify the branch affiliation of participants. Nutrition was only addressed in one study, but solely with respect to dietary supplement use [17]. There is more extensive research on similar populations, namely active- duty military and athletes that will be used as the basis for this literature review.

Data from active-duty military personnel may be generalizable to that of ROTC and vice versa. Both populations are required to meet branch-specific body composition and physical fitness standards, and failure to do so could eventually lead to administrative separation from the military or disenrollment from the ROTC program. [18, 19] Although ROTC members do not face job loss, as they are not active duty, they risk the loss of an ROTC scholarship. Thus, both populations have the same monetary and career-driven motivators to maintain a high level of physical fitness. The Virginia Tech ROTC population is particularly unique because it is one of only two universities in the U.S. where cadets are enrolled in a military college within a civilian

public university. [18] In that sense, the regimented military lifestyle of Virginia Tech cadets provides a similar environment to that of active-duty military living on military bases; with regard to nutrition, both have limited resources, time, and options in terms of their food choices.

Additionally, as aspiring officers, ROTC members represent the future leadership of the U.S. Armed Forces. While overweight and obesity rates are lower among officers than enlisted service members [20], officers have the potential to positively or negatively impact the health habits of their subordinates with their influence.[21] A 2013 study of U.S. Army personnel found that 75% of soldiers in Basic Combat Training believed their drill sergeant was helpful in making food choices for physical performance; implying military leadership may be used as a tool to promote healthy nutritional behaviors among the military as a whole. [22]

The other group of interest for the purpose of this literature review is athletes. Most of the literature surrounding sports nutrition knowledge has been collected from collegiate athlete samples. Only one existing paper, conducted in Ireland, has evaluated sports nutrition knowledge and practices in a college-aged military population, defining them as a sub-group within a sample of university and club athletes. [13] Although ROTC members may not meet the traditional definition of an athlete [23], there are many parallels between cadets and athletes.

Both athletes and ROTC cadets place a high value on physical performance. [16, 24] For both cadets and varsity athletes, their affiliation with ROTC or their team is dependent upon their ability to meet certain physical performance expectations. This performance pressure could be compounded with financial pressure to retain scholarships and long-term implications on military or athletic career goals. Because of this, ROTC cadets are more similar to varsity athletes than recreational athletes in terms of their motivation to maintain physical fitness, which may carry over into their nutritional practices. [24, 25]

Unlike recreational athletes who are motivated primarily by their love for, or their emotional connection to a sport, varsity athletes are more motivated by the need for accomplishment, desire to accomplish long-term goals, and interest in continual improvement in their sport. [24] Additionally, athletic identity, the sense of self that an individual derives from athletics, impacts motivation and may in turn influence nutritional habits. [25] The Corps of Cadets culture and its emphasis on leadership, team building, perseverance, and achievement likely promote similar sources of motivation. Physical fitness is regarded as a critical attribute of successful military leaders, but it is unclear whether or not cadets identify as athletes. [26] The military institution has been criticized for promoting a "culture of testing not fitness" [27]; so it is possible that cadets may train only to meet fitness standards, without possessing the same desire for continual improvement that is seen in varsity athletes.

While both athletes and cadets have a structured physical training regimen, a study at Florida State University suggested that ROTC physical training was not intense enough to prevent unfavorable changes in body composition. Compared to physically active civilian students, ROTC cadets were less successful in preventing weight gain in their first year of college. [14] However, it is important to note that unlike ROTC programs at other state universities, Virginia Tech Corps of Cadets provides a regimented military lifestyle including strict regulations and dormitory-style living. In that respect, Virginia Tech ROTC members are more similar to varsity athletes because engrossment in a military institution requires an equally, if not more intense time commitment and psychological commitment as a varsity sport.

Another parallel between collegiate athletes and ROTC members is the potential for a sedentary career after college. Many college athletes will not go on to play professionally after college and will alternatively, enter another career. Similarly, non-combat job duties of military

personnel, particularly officers, are unlikely to be physically tasking. [28, 29] For both of these populations, regardless of their current weight and fitness status, it is important that they understand basic concepts of weight management as they potentially transition into more sedentary careers.

Nutrition Knowledge: Why is it important?

Nutrition knowledge is only one of many factors that impacts food choices and thus impacts diet quality. [25] Although knowledge might not always translate to behavior, the literature does suggest a weak, but positive correlation between knowledge and diet quality in the general adult population. [30] This relationship between nutrition knowledge and diet quality may be especially strong among motivated populations, those with diet-related goals, and those that use food labels. [31, 32] Among college students, higher levels of knowledge of the USDA Dietary Guidelines was associated with more healthful eating behavior. [33] Additionally, college athletes with higher levels of nutrition knowledge may be more likely to have higher diet quality [34, 35], meet their energy needs [36-38], and be less likely to consume energy drinks. [39]

Despite the aforementioned positive impacts of nutrition knowledge on diet quality, the majority of adults possess an inadequate level of nutrition knowledge 30, although there tends to be a higher level of nutritional knowledge among females, and a positive correlation between nutrition knowledge and age, socioeconomic status, income, and education level. [40, 41] Athletes also show inadequate levels of nutrition knowledge, on par with that of the general population with respect to the literature as a whole. [15, 29, 30, 34, 35, 37, 39, 42-44] Few studies demonstrated that athletes have a higher level of nutrition knowledge when directly measured against a general population comparison group, but a lower level of knowledge than

nutrition students or nutrition professionals. [45, 46] Nutrition knowledge of athletes is higher among those who have taken a nutrition course and those who received nutrition education from a Registered Dietitian Nutritionist (RDN). [29, 36, 38, 47]

Before full-time RDNs became commonplace at large Division I collegiate athletic programs, coaches, strength and conditioning coaches, and athletic trainers were the primary sources of nutrition information for athletes. [48] Unfortunately, while these individuals were more knowledgeable than their athletes, the data suggest that they did not possess the necessary expertise for the provision of nutrition education. [49] Two studies with NCAA Division I athletes support the role of a RDN in this effort; athletes increased their total energy and macronutrient intake towards the recommended values after the provision of an educational intervention by a RDN. [36, 38]

Just as athletes without access to a RDN look to coaches, military personnel may look to their leadership for nutrition advice. [22] Similar to coaches and athletic trainers, a sample of 2,938 active-duty Navy personnel indicated a higher level of nutrition knowledge among officers, compared to enlisted servicemen. However, the officers' mean score of 30.1 on a basic 40-item nutrition knowledge questionnaire suggests that officers would still be inept to provide nutrition education. Additionally, in a sample of 113 Army commanders, only 7% were able to answer 10 basic nutrition knowledge questions correctly. [5]

Since then, the U.S. Army has moved towards a similar model as many collegiate and professional athletics programs, targeting nutrition knowledge with the provision of preemptive nutrition education by a RDN. The U.S. Army is actively increasing their force of commissioned dietitians, with officers serving a dual role in their military duties, and as healthcare professionals. [50] While the Army seems to have caught on to the purported benefits of

nutrition education, the U.S. Navy has not followed suit. The notion that nutrition is an important factor in combat readiness has certainly not gone unrecognized in military research. [27, 51] However, nutrition education in the Navy remains a disciplinary measure, targeted towards weight loss, rather than performance-enhancement. [6]

In learning psychology, it is well understood that acquiring new knowledge in a given area will be easier with a base of previous knowledge in that area. [52] The current nutrition education model in the Navy conflicts this consensus as sailors may not receive nutrition education until they are already overweight. [6] In the field of nutrition, research is constantly evolving, recommendations are adapting, and misinformation is rampant in the age of the internet. Having a knowledge base may help individuals sort out the facts as they are faced with new nutrition information and lifestyle changes. In that sense, regardless of one's current weight or fitness status, basic nutrition education could be an asset for all military personnel, as they navigate through a career with highly variable physical demands [28], while being continually held to high physical fitness standards.

Nutrition Knowledge: What is it?

In broad terms, nutrition knowledge encompasses an understanding of the relationship between diet and disease, the nutrient content of foods, and familiarity with current dietary guidelines. [53] Worsley et al., identifies two types of knowledge, declarative knowledge, or the understanding of nutrition concepts, and procedural knowledge, the ability to apply knowledge. [54] Procedural knowledge is distinguishable from behavior because it evaluates the ability to make theoretical choices, not the practice of the behavior itself. Within the current literature, there is no general consensus on the definition of nutrition knowledge or on what is considered an adequate level of nutrition knowledge. Perhaps this is because what is considered an

"adequate" level of knowledge varies from population to population. For instance, athletes benefit from a more comprehensive understanding of nutrition, inclusive of performance nutrition guidelines.

For that reason, much of the research on nutrition knowledge in athletes evaluates sports-specific nutrition knowledge. Similar to general nutrition knowledge, there are no universal means for defining or measuring sports nutrition knowledge. In a recent systematic review, Trakman et al., identified several sub-categories common across the variety of general and sports nutrition knowledge instruments used for athletes. These sub-categories include: weight management and energy balance, macronutrients, micronutrients, supplementation, fluids, pre-competition meal, nutrition during competition, recovery meal, and alcohol. [55] These categories align with the most recent guidelines published by the Academy of Nutrition and Dietetics and the American College of Sports Medicine on nutrition and athletic performance. [56] Sports nutrition knowledge expands on general nutrition knowledge by including information pertinent only to highly active populations that value athletic performance. Sports nutrition knowledge takes into account the higher energy needs of athletes, the heightened importance of body composition, nutrient timing, and hydration, and the relationship between diet and physical performance.

Physical Readiness

In a military population, performance enhancement may be defined in the context of physical readiness. The Department of Defense defines physical readiness as, "The overall capacity to perform the physical duty of military service and combat, consisting of the components of physical fitness, health, and motivation." [57] Specifically, the United States Navy measures physical readiness using a three-part test; a 1.5 mile run as measure of aerobic

capacity, a 2-minute push-up test as a measure of muscular strength, and a 2-minute curl-up test as a measure of muscular endurance. The validity of these measures have been called into question, and although revisions were proposed, the existing three-part test is currently the only accepted tool for measuring physical readiness. [58] Regardless of its limitations, the present physical readiness test provides standardized means of quantifying physical performance in a Navy population.

Weight Management and Energy Balance

It is well understood that body composition plays an important role in physical performance. [4] Steed et al., specifically demonstrated the importance of weight management for ROTC cadets in showing a positive correlation between body fat and 2-mile run time, and a negative correlation between body fat and number of push-ups completed on the Army Physical Fitness Test. [59] While weight manipulation has the potential to improve performance, it has equal potential to be detrimental to performance and psychological and physical well-being. [60] Increasing knowledge in this area can help encourage healthy weight management practices, and deter individuals from engaging in harmful practices and disordered eating behaviors. [61]

In general, athletes are well-informed about healthy weight management strategies. A 2002 study found that 75% of athletes understood that eating carbohydrates did not directly contribute to weight gain. [44] Both in 1987, and a more recent 2009 study, almost all athletes surveyed denounced fasting and skipping meals as a weight loss mechanism. [62, 63] However, some misconceptions have shown to withstand time; two studies, one conducted in 1996 and the other in 2014, found that the vast majority of athletes (84% and 92%, respectively) believed acidic foods such as grapefruit aided in weight loss. [64, 65]

Despite athletes' overall understanding of how to safely manipulate weight, their practices may not align with their reported knowledge. In particular, athletes in weight-specific sports, such as wrestling, are especially susceptible to the use of unhealthy measures to induce rapid weight loss. [60] Similar to wrestlers who must weigh in before competing, military personnel must meet weight and height standards before they complete the physical readiness portion of the physical fitness assessment. For that reason, military populations appear to mirror wrestlers in their tendency to engage in risky weight loss practices. Diet pills, fasting, sweat suits or saunas, and herbal or dietary supplements were some of the most common weight loss measures previously attempted by Army soldiers enrolled in a weight management program, yet only 7.4% of respondents reported having an appointment with a RDN and only 2.9% reported behavior counseling. [66] Similar data from a population of Navy sailors suggested that these dieting practices may be tied to pressure to pass physical fitness assessments. During fitness testing periods, three times as many sailors engaged in disordered eating behaviors such as self-induced vomiting and laxative use, in comparison to non-testing periods. [67] When compared with a civilian weight management group, a military weight management group was four times as likely to use self-induced vomiting, despite the fact that the civilian weight management group was 87% female while the military weight management group was only 35% female. [68]

The concern is that these short-term weight loss solutions may transpire into eating disorders. Female soldiers are at a similar risk for developing eating disorders as collegiate female athletes. In sample of 423 female soldiers in the U.S. Army, 34% were identified as "at risk" for abnormal eating behaviors, compared to a sample of collegiate athletes where 35-38% were considered at-risk for Anorexia Nervosa or Bulimia Nervosa. [69, 70] Additionally, 8% of female soldiers in the same sample were diagnosed with an eating disorder. Of those who were

diagnosed with an eating disorder, 64% noted "military pressure about weight" as an external factor contributing to their eating behaviors. [70] The same issue was seen in male military populations. In a sample of 1,425 active-duty U.S. Navy sailors, there was a 2.5% prevalence of Anorexia Nervosa, 6.8% prevalence of Bulimia Nervosa, and 40.8% prevalence for unspecified eating disorders. [71]

Despite the high prevalence of overweight and obesity in the military, under-consumption and a negative energy balance are notable issues as well. During field operations and basic combat training, the energy expenditure of soldiers mirrors that of elite athletes. [5] Similar to Relative-Energy Deficiency Syndrome in athletes, the high energy expenditure of military personnel may lead to low energy availability and a myriad of health and psychological problems, with the potential to impact combat readiness. [5, 72] Regardless of whether under consumption is driven by disordered eating, it highlights the need to improve understanding of weight management concepts.

Macronutrients

While nutrition recommendations for the general population are provided in terms of food groups, recommendations for athletes are often given in terms of macronutrients. On top of understanding basic energy balance, active individuals must be cognizant of their individual macronutrient needs, particularly carbohydrates and protein. [73] Additionally, athletes should understand the roles of each macronutrient to ensure proper nutrient timing, and be able to identify food sources of each macronutrient.

Athletes have shown difficulty in understanding of fat and differentiating between types of fat. [37, 55] Many athletes mistakenly believe that protein is the primary source of energy for muscles [43, 44, 74, 75], and do not understand their carbohydrate needs. [29, 43] Across all

studies, athletes tend to under-consume carbohydrates in comparison to sports nutrition recommendations. [34, 36, 37, 76, 77] Athletes may meet their protein needs more easily [37, 76] or even well-exceed the protein recommendations. [37] However, some data suggests athletes struggle to meet both carbohydrate and protein needs, and thus fall under their total daily energy needs. [34, 36]

Micronutrients

Although the importance of micronutrients in physical performance is well-noted, the micronutrient Dietary Reference Intakes for athletes are no different than the general population. While most athletes should be able to meet their micronutrient needs with whole foods alone, the consequences of micronutrient deficiencies may be amplified in active populations. Micronutrients play essential roles in energy metabolism, bone health, hydration, and as antioxidants. [78] Understanding the roles of micronutrients may incentivize athletes to consume more nutrient-dense foods, provided that they are also knowledgeable with regard to food sources of micronutrients.

While there is no data regarding the knowledge of micronutrients in military populations, the Health-Related Behavior Survey of Active Duty Military Personnel and the Army Food and Nutrition Survey assessed dietary intake of different food groups. Respondents reported frequent consumption of foods lacking micronutrients, such as sugary drinks, sweets, and snack foods. In contrast, they appear to under-consume nutrient-dense foods such as whole grains, fruits, vegetables, and dairy. [1, 79] Only 11-13% of individuals met the daily recommendations for fruits, vegetables and whole grains. [1] Among 312 U.S. Army soldiers enrolled in a weight management program, 57% of respondents ate one or less servings of fruit per day and 46% ate one or less servings of vegetables. [66] Taken together, this suggests that military personnel

consume inadequate amounts of micronutrients from whole foods and may lack knowledge in this realm.

Of the 36 studies reviewed by Trakman et al., 31 included questions related the micronutrients in their assessment of nutrition knowledge. However, there is little uniformity in the instrumentation used to assess knowledge of micronutrients and few studies discuss responses to specific questions. Of the papers addressing micronutrients, the most commonly used instrument was the 76-item True/false questionnaire created by Zawila et al. [34, 63, 80-84], but only three papers addressed specific gaps in knowledge in the discussion [63, 81, 82]. Because of this, the existing data should be interpreted with caution.

In a sample of 30 collegiate female hockey players, participants were well-informed regarding the role of iron and consequences of deficiency, but were less successful in identifying iron sources. [81] This is supported by data from two separate questionnaires, where athletes believed that milk was a good source of iron [85], and the primary micronutrient in spinach was iron. 86 Similarly, Hoogenboom et al., found that despite consuming adequate amounts of iron, female collegiate athletes rarely listed heme sources of iron on their dietary recalls. The majority of their iron intake came from fortified foods, indicating a potential lack of knowledge surrounding iron sources. [84] In contrast, other data from a separate questionnaire suggested a high level of procedural knowledge, as the majority of athletes were able to correctly answer questions regarding food sources of potassium, calcium, and vitamin C. [65]

Rash et al., assessed both knowledge and dietary intakes of calcium, potassium, sodium, Vitamin A, Vitamin C, and Vitamin E of 113 NCAA Division I track athletes. The majority of athletes mistakenly believed that Vitamin C supplementation is necessary to boost immune system function and that Vitamin E supplementation is necessary to “protect red blood cells from

oxidative damage and to promote oxygen transport to muscles". However, these identified gaps in knowledge did not correlate with dietary intake; athletes consumed inadequate amounts of Vitamin E but adequate amounts of Vitamin C. [82]

Another possible common misconception was that micronutrients are a source of energy. More than half of participants (56%) in both American and Nigerian samples of collegiate athletes answered true to the statement "Vitamins are a good source of energy". [34, 82] Likewise, on a separate questionnaire, 50% of athletes thought that multivitamin supplements increase energy levels and 45% agreed that multivitamins are "vital for topping off performance". [87] Despite the high level of variability in instrumentation, taken together, these findings highlight important misconceptions that may partially explain supplement use trends and related gaps in knowledge.

Supplementation

Despite the high energy needs of athletes and the role of micronutrients in performance, most individuals should be able to meet their macro- and micronutrient needs with food sources alone. [88] The lack of knowledge regarding food sources and roles of macronutrients and micronutrients may lead to over-reliance on dietary supplements and erroneous beliefs regarding the need for their use.

Supplement use and supplement-related knowledge is one of the few areas where data exists specifically for an ROTC population. In a recent paper by Valentine et al., supplement knowledge and use was investigated for ROTC cadets, student athletes, and normal undergraduates at the same university. Fifty percent of cadets reported supplement use, in comparison to 54% of student athletes and 58% of other undergraduate students. Most ROTC cadets reported using 5-10 different supplements, with an average of 8.3 different supplements,

compared to averages of 7.1 and 6.5 different supplements in the athlete and undergraduate student samples. Among supplement-users, protein supplements were the most widely reported, followed by energy supplements, multivitamins/minerals, single vitamins or minerals, pre-workout, carbohydrate supplements, creatine, weight loss supplements, and lastly herbal supplements. When asked about the effectiveness of supplements in certain categories, 83% of cadets were confident in the effectiveness of supplements for health and wellness promotion, followed by muscle building (78%), and physical performance (76%). These high levels of confidence in the efficacy of supplements were seen despite the fact that two-thirds of ROTC supplement-users also reported experiencing an adverse event. None of these adverse events were reported, suggesting a general lack of knowledge and disregard for the risk of supplements. While 69% of cadets felt that they were either somewhat or very knowledgeable about supplements, their primary source of information was the internet and only two cadets had looked to a RDN for information. [17, 89]

In comparison to ROTC cadets, active-duty military populations exhibit similar prevalence and attitudes towards supplement use. In the 2011 Department of Defense report of active duty military members, 57% were taking multivitamins, 40% reported taking individual vitamins, and 33% reported the use of legal bodybuilding supplements. [1] Compared to the general population, performance enhancement and weight loss are cited more often as the reasons for use among military members. [90, 91] Longitudinal data shows increasing dietary supplement use among U.S. Army soldiers driven by younger age cohorts. In four years, between 2006-2007 and 2010-2011, overall supplement use in the Army increased from 56% to 64%, but the 18-24 age cohort alone saw more than a 20% increase in supplement use.

This trend corresponds to the popularity of protein supplements across all college-aged populations explored by Valentine et al. While consumption of other supplements has remained fairly static, consumption of protein supplements and "combination supplements" (supplements containing multiple ingredients, such as pre-workout supplements) have seen a notable increase. [92, 93] Protein supplement use among military member now mirrors that of athletes. [28] A 2014 study of the Navy and Marines suggests supplement use has continued to climb with 73% of respondents reporting supplement use. [94] Currently, supplement use in the military exceeds the 52% prevalence of supplement use in the civilian population, and military personnel are more likely to use multiple supplements, increasing the risk for adverse effects. [95, 96]

While none of the existing literature evaluates nutrition knowledge of American military populations using a sports-specific questionnaire, various studies have shown gaps in nutrition knowledge regarding supplementation. Similar to athletes, military personnel tend to be overconfident in the safety of supplements and unaware of the lack of government regulation. [97] Additionally, 60% of protein supplement users in the Army noted "greater muscle strength" as their reason for consuming a protein supplement. In both ROTC and active duty military populations, those who engage in strength training are more likely to use dietary supplements. [1, 17] This correlation may be indicative of a desire to increase strength and improve physical performance through nutrition, but a lack of sports nutrition knowledge regarding the appropriate methods to do so.

Unlike collegiate and professional athletic programs, the military does not have universal procedures in place for education or regulation related to dietary supplements. "Operation Supplement Safety" (OPSS) was launched by the Department of Defense in 2012 as their first attempt to provide a universal education protocol for supplement use. However, two years after

the website launched in 2014, a survey showed that only 21% of respondents knew about the resource. [95] While this effort is an improvement, it currently serves only as an available resource for inquiry, rather than a preventative form of education. Adverse effects of supplements may be especially dangerous for military populations depending on their job specificity. For instance, hypoxia could be a relatively harmless short-term side effect of supplements for the average population, but it could be deadly for an aviator. Supplements are readily available on military bases, often for a discounted price and tax-free, and this availability may be misconstrued as an outright promotion of supplement use. In 2013, a 22-year old Army Private died after taking a pre-workout supplement that he purchased at a GNC store on base. Additionally, the weight-loss supplement, Hydroxycut was attributed to the development of exertional rhabdomyolysis in three U.S. Army soldiers. [98] Despite this, GNC still has stores on-base in multiple locations across forty states, and supplements can also be found at the commissary, exchange, and in fitness centers. [99]

Fluids

Hydration status has drastic implications for physically active individuals who are prone to fluid loss. Dehydration can be detrimental to athletic performance with consequences ranging from headache, to increased exertion from lack of blood flow, to impaired recovery. Furthermore, both dehydration and hyperhydration can lead to deadly consequences through heat stroke or hyponatremia. [100] The importance of hydration is well recognized in both athletic communities and in the military. The U.S. military has set forth specific fluid replacement guidelines for which commanding officers are responsible for implementing. [25, 101] Military training and operations often require similar physical exertion to intense athletic training, but this may be coupled with exposure to extreme heat or humidity, extreme cold, or high altitudes, as

well as the possibility of limited fluid supplies. [101] Maintaining cognitive function through euhydration is especially important for those in combat zones or other stressful environments, such as aviation. In a sample of 40 U.S. Army pilots, those that were dehydrated with a loss of 1-3% of their body weight exhibited impaired flight performance and spatial cognition. [102]

In general, fluid replacement is an area of nutrition where athletes are very knowledgeable, with upwards of 90% of correct responses for hydration-related questions. [44, 55, 65] However, lower levels of knowledge may be seen on a more comprehensive questionnaire. An 88-item nutrition knowledge questionnaire, developed by Zinn et al., addresses more advanced recommendations, such as the appropriate amount of carbohydrate in a sports drink and the threshold for fluid loss in terms of percentage of body weight. [103] When given this questionnaire, the mean score for nine hydration-related questions was 56% in a sample of 346 Irish athletes. In accordance with their knowledge level, there was a high prevalence of dehydration among these athletes with 32% commencing training in a dehydrated state, and 44% finishing training dehydrated, with a urine specific gravity over 1.020. This particular sample also included a group of army cadets. The cadets had the highest prevalence of dehydration prior to training, however, their body weight did not change and they exhibited the lowest mean change in urine specific gravity between pre- and post-exercise measurements. This finding implies that the rigor of training for cadets may not pose the same risk for dehydration as that of athletes. It is unclear whether the training intensity is generalizable to American ROTC cadets, however, a similar prevalence of dehydration prior to exercise was found in a sample of U.S. Army officers with 33% of soldiers being dehydrated prior to starting their Army Physical Fitness Test. No correlation was found between hydration status and performance on the Army Physical fitness test, but it is important to note that hydration status was evaluated with urine

specific gravity, and may not have accurately represented the <2% of body weight guideline. Additionally, the impact of hydration status on physical performance may not overcome individual factors and physical fitness level, and thus would be more appropriately evaluated using an experimental cross-over design. 104

Only one study of nutrition knowledge in an active-duty military population reported specifically on a hydration sub-score. Of five categories, U.S. Army soldiers scored the highest on hydration, with a mean score of 60% on eight questions. [105] This score was not discussed or qualified in any way by the authors but it likely represents an inadequate level of knowledge on such a critical issue. The existing literature provides limited insight into the specific hydration practices of military and ROTC populations, but in 2016 alone, there were 2,536 reported cases of heat illness among active-duty military members. [106] The high incidence of hydration- related problems cues the need to investigate both knowledge and practice of proper fluid replacement guidelines.

Nutrient Timing (Pre-Competition Meal, Nutrition During Competition, Recovery Meal)

For optimal performance and recovery, athletes must consider what and how much they eat before, during, and after practices and games. [56] Similarly, ROTC cadets and active-duty military personnel should follow the same practices in fueling for physical training (PT) sessions, fitness tests, and military operations. Unfortunately, meaningful conclusions cannot be drawn from the existing data due to the limited discussion of responses to specific question items. [107] However, the previously mentioned knowledge gap related to carbohydrate needs [29, 43], combined with the prevalence of low-carbohydrate diet fads [43], and the popularity of protein supplements [17, 28], suggest that athletes may not understand the importance of fueling with carbohydrates at all three stages; before, during, and after intense exercise.

Alcohol

Compared to an estimated 27% prevalence of binge drinking among the general population, 33% of active-duty military personnel and 38% of college students report binge drinking. [1, 108] The primary concern of this behavior is that it may impair physical performance through its direct effects on hydration status, inflammation, and muscle protein synthesis. Binge drinking may also indirectly harm athletes and cadets alike in that it is likely to influence energy balance and has the potential to lead to unfavorable weight gain. In that sense, binge drinking may be especially harmful to those under pressure to meet weight requirements and encourage disordered eating behavior. Heavy drinkers, especially women and those with weight control motivations, tend to purposefully restrict food intake to account for their energy consumption through alcohol. [109] Doing so may be harmful from both a psychological and performance standpoint, as it may transpire into other disordered eating patterns and encourage improper fueling practices. Despite the well-understood implications of alcohol consumption for performance, there is no meaningful descriptive data regarding athletes' knowledge of these concepts.

Current Limitations and Gaps in Literature

Instrumentation

The primary limitation in assessing nutrition knowledge is the lack of uniformity and validity in instrumentation for this population. Because of this, it is nearly impossible to conduct a comprehensive review of nutrition knowledge and determine widespread gaps in knowledge. [55] The knowledge assessment tools most commonly used for athletes are the validated questionnaires by Parmenter et al. [110], Zinn et al. [103], and Zawila et al. [83] Furthermore,

there is no research using validated nutrition knowledge questionnaires within ROTC or U.S. military populations, as the limited data in this realm relies on self-developed questionnaires. [8, 9, 105] In both cases, these questionnaires focused too heavily on declarative knowledge of nutrition principles, rather than procedural knowledge or the ability to apply these principles. Nutrition knowledge should be thought of as a skill-set and questionnaires that do not address procedural knowledge may not produce meaningful data. [54] Additionally, many were outdated and lacked relevance to current guidelines and adequate validation. [55] Trakman et al., recently produced and validated an updated instrument, the "Nutrition for Sport Knowledge Questionnaire" (NSKQ). Currently, this is the most appropriate tool to assess sports nutrition knowledge. [111] However, the NSKQ was developed in Australia and intended for international use. Thus, the questionnaire required minor modifications to reflect American taste preferences and units of measure. Minimal content modifications were also necessary to prevent an overemphasis on declarative knowledge, and to reflect the most recent sports nutrition recommendations.

Physical Performance and Body Composition as Correlates of Nutrition Knowledge

Limited research exists on the correlation between nutrition knowledge and physical performance or nutrition knowledge and body composition. A study of Nigerian collegiate athletes found no correlation between nutrition knowledge and athletic performance. However, this finding is likely due to the fact that grip strength on a hand dynamometer was used as the sole measure of athletic performance. [34] Cholewa et al., found that NCAA Division I athletes receiving nutrition education improved significantly more on the 5-10-5 shuttle test than the control group. [36] However, there were no significant differences on three other performance measures. Additionally, while both the intervention and control group increased both their lean

body mass and total body mass, only the intervention group was successful in improving their body fat percentage. [36]

A separate study of NCAA Division I athletes collected similar data to Cholewa et al., on dietary intake, body composition, and performance measures. However, this study was purely observational and no correlations were drawn between diet and performance. [112] In the same respect, a number of historical military reports presented descriptive data on nutrition knowledge, diet quality or practices, body composition, and fitness test scores, but they did not attempt to draw any correlations between these constructs and in some cases failed to provide any statistical analyses of the data. [1, 79, 113, 114] Presumably, the lack of data in this area may be related to the perception that the behavior (food intake) always precedes the relationship between nutrition knowledge and performance. [115]

Relevance and Current Concerns in the U.S. Navy

Emerging Research: Comparisons between the U.S. Army and U.S. Navy

With the launch of their Performance Triad Initiative, the Army identified curriculum knowledge, diet quality, and physical fitness test performance among various other, outcome measures of interest. This is an emerging area of research and efficacy data is not yet published, nor is it clear how nutrition knowledge is being assessed. [116] In an observational study conducted to support the need for the Performance Triad, the Army assessed the relationship between eating habits, quantified by a five-item Healthy Eating Score (HES-5), and physical fitness test performance. Those that passed their physical fitness test within the top quartile were twice as likely to receive high HES-5 scores as those that failed. [117] No similar research has been conducted in a Navy population, and this may contribute to the lack of comparable performance nutrition initiatives in the Navy.

The only performance-focused nutrition education program in the Navy is their "Mission Nutrition Course", offered sporadically at fitness centers on Navy bases. This is an intensive two-day, eight hour course covering a spectrum of topics from basic nutrition, to weight control, to supplements and performance nutrition. In contrast to the Army's Performance Triad Initiative which is woven into military training and the built environment, the Mission Nutrition Course is lecture style and provides no opportunities for individualized guidance, experiential learning, or mastery experience. Additionally, the course is taught by certified instructors, rather than RDNs. The course is entirely optional and sailors must sign-up on their own initiative, compared to the Performance Triad which the Army intends to implement branch-wide. There is no data regarding the participation or efficacy of the Mission Nutrition Course, but it is inherently limited in its design, and the time commitment required suggest that it is likely an under-utilized resource. [118, 119]

Navy Physical Fitness Assessments and Fitness Enhancement Program

The U.S. Navy physical fitness assessment tests include two components, the body composition assessment and the physical readiness test. The body composition assessment evaluates weight status using height and weight standards and body fat estimation equations (based on waist, neck, and hip circumference), if necessary. The physical readiness test includes a 1.5-mile run, two-minute curl up test, two-minute push-up test, a 500-yard swim, and a 450-meter swim (the swims are not included at the ROTC level). [18, 120] Failure to meet body composition standards in the body composition assessment results in failure of the entire physical fitness assessment (PFA), regardless of scores on the physical performance component. Previously, three failed physical fitness assessments within a four year time period results in "administrative separation", cueing the end of one's military career. [120] However, in

December 2017, these consequences were loosened so that sailors must pass their fitness tests before promotion, but will not face administrative separation on the basis of PFA failure. [121]

Upon the first failed PFA, sailors are enrolled in the Fitness Enhancement Program. This program includes mandatory personal training sessions, completion of mock fitness assessments, weekly weight documentation, and nutrition education. Nutrition education through the Fitness Enhancement Program is the only form of universal mandatory nutrition education within the U.S. Navy. Thus, sailors' first exposure to nutrition education occurs only after they have already failed to meet the physical fitness assessment standards. [19]

The nutrition education component of the Fitness Enhancement may take different forms at the individual's discretion. The first option is the completion of "Shipshape", the Navy's universal weight management program, a weight-loss focused curriculum taught over eight sessions by a certified facilitator. Sailors may also meet individually with a RDN and complete a minimum of four appointments. Lastly, sailors may participate in an approved commercial civilian weight-loss program, at their own expense. [6] Although the Navy has made efforts to improve the quality of nutrition education with its revision of the "Shipshape" program in 2015, the resource remains retroactive. [19]

Failure Rates and Implications

A 2015 study of 313,513 U.S. Navy sailors assessed performance on the body composition assessments. Based on BMI, 14% of sailors were categorized as obese and 2%, or about 6,270 sailors, failed their body composition assessment. [122]

Although 2% may not seem significant, that reflects only one branch, and even a small attrition rate results in monetary consequences. A 2006 study of TRICARE prime beneficiaries estimated that overweight/obesity-related losses in productivity cost the Department of Defense

$167 million. Aside from the effect of weight status on the viability and productivity of military operations, the military health system serves 9.2 billion service members and dependents through TRICARE. Costs for overweight/obesity-related medical conditions were estimated at $1.1 billion annually in 2006. [123]

Aside from the implications for the military itself, the risk of attrition can affect the psychological well-being of the individual. Overweight individuals in the military may experience weight-discrimination and resort to dangerous dieting practices to avoid attrition. [66]

Conclusion

It is widely accepted that proper nutrition enhances physical performance of the general population. [4] Providing universal nutrition education as a preventive measure has the potential to not only reduce weight- related attrition rates, but to improve the physical fitness of the military as a whole.

Unfortunately, the perceived emphasis on the appearance of physical fitness over and above physical performance may undermine the importance of nutrition. [3, 5] Appropriate documentation and evaluation of programming is crucial in supporting the importance of nutrition education. This effort requires the use of a validated tool to measure sports nutrition knowledge as an outcome measure. Furthermore, simply evaluating nutrition knowledge and food behaviors as outcomes will likely be insufficient tactics to promote nutrition education in such an extrinsically-motivated population. Outcomes of concern to the military institution, namely, performance on physical fitness assessments should be evaluated in relation to nutrition knowledge and diet quality. A correlation between these constructs would uphold the value of nutrition as a performance enhancer and preventive measure and pave the way for policy changes to move the Navy towards universal nutrition education.

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Chapter 2: Exploration of Sports Nutrition Knowledge, Nutrition Practices and Physical Performance on Standardized U.S. Navy Physical Fitness Assessments in a ROTC Population

Introduction

Physical fitness is highly valued within the U.S. Armed Forces as a determinant of combat readiness.[1] The ability of military members to uphold this value is assessed through their respective military branch with the use of branch-specific anthropometric and physical performance standards. Despite this, the military is not immune to the problem of overweight and obesity that exists within the civilian adult population. Over two-thirds of the U.S. military is considered overweight or obese, and the majority practice poor dietary habits. [2] The current weight status of military personnel endangers combat readiness and productivity, contributes significantly to the cost of federally funded healthcare, and puts the individual at risk for administrative consequences, extending to discharge from the military. [3-5]

Compulsory meetings with a Registered Dietitian Nutritionist (RDN) are often included as consequences for failure to meet fitness standards in the military. [6] The U.S. Army is moving towards a model similar to that of many collegiate and professional sports teams, offering preemptive nutrition education as part of a multidisciplinary team including RDN, Athletic Trainers, and Strength and Conditioning Coaches. [7] Efficacy research on the Army's nutrition initiatives is ongoing, and evaluations of interventions in collegiate settings support the role of RDN in improving athletes' fueling practices. [8,9] Despite these advancements in the Army, nutrition education in the U.S. Navy remains retroactive, targeting only weight management and neglecting the potential role of nutrition in performance enhancement. [6, 10] There is limited data regarding the nutrition knowledge of this population [11,12], a key factor in designing a nutrition education intervention. Additionally, the existing

research primarily addresses general nutrition knowledge, failing to identify military personnel as athletes and neglecting nutrition concepts specific to performance enhancement, termed sports nutrition knowledge. [11,12]

The majority of existing research on sports nutrition knowledge examined American collegiate athletes, and instrumentation across studies lacks homogeneity. However, Trakman et al., recognized common categorical themes across questionnaires, identifying the sub-sections of sports nutrition knowledge as weight management, macronutrients, micronutrients, supplementation, fluids, nutrient timing (pre-, during, and post workout meals), and alcohol. [13] The Nutrition for Sports Knowledge Questionnaire (NSKQ) was developed from these themes as a validated tool to measure sports nutrition knowledge, but requires additional modifications before it is appropriate for American populations. [14] Regardless of the validity of the NSKQ, the subsections of sports nutrition as defined by Trakman et al., are relevant to both competitive athlete and military populations.

Similar to athletes, military personnel face pressure to meet military weight requirements and maintain a high level of physical fitness. [15] This produces similar disordered eating behaviors as those seen in weight-specific sports, [15, 16] and may influence military populations to use supplements at higher levels than the general civilian population. [17-20] The energy needs of military personnel may be similar to those of elite athletes under some circumstances, while their occupational duties may be mostly sedentary in others. [21,22] Military personnel must understand appropriate sports nutrition practices in order to adjust to variances in energy expenditure and maintain combat readiness throughout their career. Proper fueling practices not only have the capacity not only to help military members maintain a healthy weight and high fitness level [23], but they are crucial in high-risk environments such as combat zones, high-

altitude training, and in aviation. [18,24] Additionally, prioritizing nutrition on an organizational level may decrease the cost of overweight and obesity related illnesses, decrease rates of injury, and thereby ensure a deployable and productive military force. [5,25]

Based on the Social Ecological Model, behavior is a product of intrapersonal factors, interpersonal factors, institutional factors, community factors, and public policy. [35] Nutrition knowledge is as an intrapersonal factor impacting eating behaviors. Military officers may influence the eating behaviors of their subordinates [28], thereby impacting the greater military population and surrounding military community, including civilian dependents. [36] Military families exist as a bridge between the military community and greater civilian population. [36] Thus, a nutrition education intervention targeting the future leadership of the military has the potential to produce broader population health outcomes. Although military officers are only a small subset of the American population, their influence on military and civilian communities makes them an ideal target population.

Recognizing the parallels between the military and traditional-defined athletes and the relevance of sports nutrition in combat readiness, the present study aimed to assess sports nutrition knowledge, nutrition practices, and performance of military fitness tests using a convenience sample of Navy Reserve Officer Training Corps (NROTC) midshipmen at Virginia Tech. The purpose of this study was two-fold: 1) validate an 86-item modified Nutrition for Sport Knowledge Questionnaire (M-NSKQ) using 15 Registered Dietitian Nutritionists (RDN) from across the country, and 2) assess sports nutrition knowledge, nutrition practices, and performance on physical fitness assessments (PFA) in the Naval Reserve Officer Training Corps (NROTC) at Virginia Tech. Exploring knowledge gaps and common nutrition practices within NROTC population will inform future nutrition interventions.

Materials and Methods: Aim 1, Questionnaire Development

Participants: RDNs and NROTC Staff

Registered Dietitian Nutritionists (RDN) were recruited for the purpose of establishing concurrent and content validity of the modified questionnaire. RDN and board certified specialists in sports dietetics (CSSDs) were chosen for their expertise in sports nutrition and ability to provide feedback regarding the content of the questionnaire. Additionally, a Navy ROTC staff member was recruited as existing research suggest that military officers may influence the eating behaviors and nutrition knowledge of their subordinates, thus their scores could be used for comparison against RDN's scores. RDNs were recruited directly via email through the professional network of the researchers. Additionally, sports dietitians were specifically recruited through the Collegiate and Professional Sports Dietitians Association forum. Naval ROTC staff members, including the Captain, Commander and Company Advisors to the NROTC unit at Virginia Tech were recruited directly through email. This study was approved by Virginia Tech's Institutional Review Board (**Appendix A**).

Study Design

Participants received an email including the Informed Consent Document and a link to an online survey through Qualtrics. Participants were asked to provide their occupation, degrees and certifications, but no identifying information was collected. The survey contained an 82-item Modified Nutrition for Sport Knowledge Questionnaire (M-NSKQ), modified from the 89-item Nutrition for Sport Knowledge Questionnaire (NSKQ) by Trakman et al. [14] The majority of the format and content of the original questionnaire was preserved to uphold the validity of the questionnaire. However, questions were removed and altered to make the questionnaire culturally appropriate and reflect findings from the literature review. The "sports nutrition" subsection from the original questionnaire was further divided into "hydration" and "nutrient timing" subsections. Specific modifications and the rationale for those modifications are detailed in **Appendix B**.

One point was awarded for each correct answer, with the lowest possible score of zero points and the highest possible score of 82 points. The questionnaire key and scoring guide are included in **Appendix C**. After each subsection, participants were given space to provide open-ended qualitative feedback. Qualitative feedback is included in **Appendix D**.

Data Analysis

Responses were analyzed quantitatively by running a frequency analysis for responses to each question. Quantitative and qualitative feedback was assessed in correspondence with a team of sports dietitians with the CSSD certification. Questions answered incorrectly by 50% or more of respondents were specifically addressed and revised.

Materials and Methods: Aim 2, Assessment of NROTC Midshipmen

Participants: Midshipmen

Midshipmen were recruited from the NROTC unit at Virginia Tech. The NROTC staff provided an email contact list of midshipmen to the researcher. The midshipmen (N=202) were contacted directly via email with an invitation to participate in the study. Midshipmen were eligible to participate if they were enrolled in the NROTC, over the age of 18, and if they agreed to disclose their PFA data to the researcher. This study was approved by Virginia Tech's Institutional Review Board (**Appendix A)**.

Study Design

Naval ROTC Cadets completed their PFA for the Spring 2018 semester between January 19 and January 25, 2018. PFA measures were collected and recorded by the NROTC staff as part of a routine procedure to be provided to the researchers as secondary data.

An email invitation was sent out to perspective participants (N=202) on February 27, 2018, which included the Informed Consent Document and an email link to an online survey through Qualtrics. The survey included three parts: 11 demographic questions, an 86-item Modified Nutrition for Sport Knowledge Questionnaire (M-NSKQ), and a 37-item nutrition practices questionnaire.

A list of individuals who completed the Qualtrics survey was provided to NROTC officials. NROTC officials then compiled PFA data for each research participant, to be matched to their survey data. All identifying information was deleted after PFA and survey data were matched.

Materials

Online Survey Part 1: Demographic Questions

These questions captured potential covariates including grade level, major, previous nutrition education, sources of nutrition information, dietary restrictions, and athlete identity. This section of the questionnaire also asked participants to self- rate their nutrition knowledge and diet quality. (**Appendix E**)

Online Survey Part 2: Modified Nutrition for Sport Knowledge Questionnaire (M-NSKQ)

This section of the survey included 86 items in seven subsections: weight management, macronutrients, micronutrients, hydration, nutrient timing, supplementation, and alcohol. These questions were revised from the 82-item Modified Nutrition for Sport Knowledge Questionnaire (M-NSKQ) based on data gathered from the validation survey. One point was awarded for each correct answer, with the lowest possible score of zero points and the highest possible score of 86 points. Subscores were calculated for each of the seven subcategories: weight management (16 points), macronutrients (27 points), micronutrients (16 points), hydration (4 points), nutrient timing (7 points), supplementation (13 points), and alcohol (7 points). The questionnaire key and scoring guide are included in **Appendix F.**

Online Survey Part 3: Nutrition Practices Questionnaire

This section of the survey included 37 items assessing nutrition practices. Questions were developed to assess behaviors corresponding to M-NSKQ. These questions assessed weight management practices, usual dietary consumption, supplement use, hydration practices, nutrient timing and sports-specific nutrition practices, and alcohol use. The questions assessing alcohol consumption were derived from the National Institute on Alcohol Abuse and Alcoholism, [26] and all other questions were self-developed. The questions included multiple choice, multiple response tick boxes, and Likert-scale style questions. (**Appendix G**)

Physical Fitness Assessment (PFA) Data

The physical fitness assessment includes the body composition assessment and the physical readiness test. The physical readiness test for Navy track midshipmen consisted of a 1.5-mile run, two-minute curl up test, and two-minute push-up test, while the physical readiness test for the Marine Corps track midshipmen consisted of a 3-mile run, two-minute curl-up test, and a pull-up test for men or a flexed-arm hang test for women. Physical readiness scores were given in terms of run-time, number of curl-ups, and number of push-ups or pull-ups (or flexed-arm hang time), as well as a quantified score for each section of the test, and an overall physical readiness score. Physical readiness scores were grouped to one of five ordinal categories: failure/satisfactory, good, excellent, outstanding, and max.

Statistical Analysis

All statistical analyses were conducted with IBM SPSS Version 24. Bivariate Pearson correlations with a predetermined significance level of $p \leq 0.05$ were run on M-NSKQ scores, body composition assessments (using computed BMI from height and weight data), and physical

readiness test scores. The same correlations were run with participants stratified by sex, race, nutrition education history, and athlete identity. A one-way ANOVA test was used to compare mean M-NSKQ scores across grade level, sex, race, self-rated nutrition knowledge, athlete identity, and nutrition counseling history. A frequency analysis of responses to individual questions was examined to determine the percentage of correct and incorrect responses for each item on the M-NSKQ. Frequencies of sex and race were compared between enrolled participants, NROTC at Virginia Tech, and active-duty Navy officers to assess representativeness.

Results

Aim 1, Questionnaire Development

Participants: RDNs and NROTC Staff

A total of 18 responses were submitted. This included two partial and 15 full responses from RDNs, and one full response from an Assistant Professor of Naval Science and NROTC staff member. The two participants with partial surveys were excluded from the analysis. Of those responses, nine RDNs listed Board Certified Specialist in Sports Dietetics (CSSD) as an additional credential. “Sports dietitian”, “sports nutrition” or “performance dietitian” were in response to “What is your occupation?” in 11 cases. The sample included one response from a U.S. Army Performance Dietitian.

Modified Nutrition for Sport Knowledge Questionnaire (M-NSKQ) Scores

The mean total nutrition knowledge score for all RDNs (n=15) was 84% on the 82-item questionnaire. RDNs scored the highest in the nutrient timing, alcohol, and macronutrient subsections with mean scores of 97%, 91%, and 90% respectively. The lowest mean score was in

hydration with a 65%. RDNs that listed a CSSD credential scored higher (but not statistically significant) than RDNs without a specialization in sports dietetics, with a mean total M-NSKQ score of 87%, compared to 82% for non-sports dietitians. In comparison to the mean score of 84% for all RDNs, the one NROTC staff member only answered 54% of items correctly. **See Table 1.**

Table 1. Mean M-NSKQ* Scores for Registered Dietitian Nutritionists and Sports Dietitians

M-NSKQ (maximum points)	All Registered Dietitian Nutritionists (RDN), n=15 (Mean Score ± Standard Deviation)	RDN with Board Certified Specialist in Sports Dietetics (CSSD) Credential, n=9 (Mean Score ± Standard Deviation)	RDN without CSSD credential, n= 6 (Mean Score ± Standard Deviation)	One-way ANOVA (non-CSSD RDN vs. CSSD)	
				F Statistic	P-value
Total Score (82 points)	69.3 ± 4.4	70.7 ± 3.9	67.2 ± 4.5	2.596	0.131
Weight Management (12 points)	10.5 ± 1.7	10.3 ± 2.0	10.7 ± 1.2	0.132	0.722
Macronutrients (24 points)	21.6 ± 1.5	21.9 ± 1.6	21. 2 ± 1.2	0.881	0.365
Micronutrients (16 points)	12.9 ± 1.2	13.1 ± 1.1	12.7 ± 1.5	0.457	0.511
Hydration (4 points)	2.6 ± 0.7	2.7 ± 0.9	2.5 ± 0.6	0.173	0.684
Nutrient Timing (7 points)	6.8 ± 0.6	6.9 ± 0.3	6.7 ± 0.8	0.547	0.473
Supplementation (11 points)	9.0 ± 1.9	9.8 ± 1.6	7.8 ± 1.9	4.609	0.051
Alcohol (7 points)	6.4 ± 0.6	6.6 ± 0.5	6.2 ± 0.8	1.400	0.258

*M-NSKQ= Modified Nutrition for Sport Knowledge Questionnaire

M-NSKQ Modification

There were six questions answered incorrectly at least 50% of the time by RDNs. All of these items were evaluated, five were revised and one was removed from the questionnaire. **Table 2** details the revisions to the five questions that were maintained in the modified questionnaire. The removed question concerned food sources of protein. In the previous questionnaire, food sources of macronutrients were assessed in groups of questions by asking, "Do you think these foods are high or low in [carbohydrates/ protein/ fat]?" Most of the comments in the qualitative feedback mentioned the allusiveness of these items. These questions were revised to ask, "Do you think these foods are significant sources of [carbohydrates/ protein/ fat]?" Additionally, "significant" was quantified as at least 15 grams for carbohydrates (based on the amount of one carbohydrate exchange), 7 grams for fat (based on 10% of the recommended daily value), and 7 grams for protein (based on the amount of a one ounce-equivalent). The food sources in question were also revised to be more culturally appropriate and additional items were added to assess a wide range of foods for each macronutrient. In total, four items were added to the questionnaire, to create the final modified 86-item M-NSKQ.

Table 2. Modifications to M-NSKQ Items with >50% Incorrect Response Rate*

Original Question	Modified Question
Thiamine (Vitamin B1) is required for the efficient delivery of oxygen to muscle. ➢ Agree ➢ Disagree ➢ Not sure	Thiamine (Vitamin B1) is required for energy production during aerobic exercise ➢ Agree ➢ Disagree ➢ Not sure
Sweet potatoes are higher in potassium than white potatoes ➢ Agree ➢ Disagree ➢ Not sure	Baked potatoes are high in potassium ➢ Agree ➢ Disagree ➢ Not sure
Athletes have increased magnesium needs due to losses in sweat ➢ Agree ➢ Disagree ➢ Not sure	Athletes with a higher sweat rate may have increased magnesium needs ➢ Agree ➢ Disagree ➢ Not sure
Athletes should drink water during activity in order to: Choose one answer ➢ Maintain plasma (blood) volume ➢ Prevent dry mouth ➢ Maintain sweat volume ➢ All of the above ➢ Not sure	Athletes should drink water during activity in order to: Choose one answer. ➢ Maintain plasma (blood) volume ➢ Regulate body temperature ➢ Avoid abnormal increases in heart rate ➢ All of the above ➢ Not sure
Regarding fluid intake during physical activity, current recommendations encourage athletes to: Choose one answer ➢ Drink 50-100 mL (1.7-3.3 fluid ounces) every 15-20 minutes ➢ Suck on ice cubes rather than drinking during training ➢ Drink sports drinks (e.g. Gatorade) instead of water when exercising ➢ Hydrate according to changes in body weight that occur during training sessions	Regarding fluid intake during physical activity, current recommendations encourage athletes to: Choose one answer. ➢ Drink 50-100 mL (1.7-3.3 fluid ounces) every 15-20 minutes ➢ Suck on ice cubes rather than drinking during training ➢ Avoid sports drinks to limit added sugar consumption ➢ Hydrate according to changes in body weight that occur during training sessions (individual sweat rate)

*Underlined text indicates the correct response.

Aim 2, Midshipmen Sports Nutrition Knowledge, Nutrition Practices, and Physical Fitness Assessment Scores

Participants

Two hundred and two individuals were contacted. After filtering for ineligible and incomplete responses (n=27), there were 102 participants included in the analysis, which reached 51% of the Virginia Tech NROTC population. Of these, 12 midshipmen were Marine Corps track, and 90 were Navy track. The sample was composed of 37% freshmen, 18% sophomores, 19% juniors, 22% seniors, and 4% 5th year students or alumni. Eight-two percent of participants were males and 18% were females, and 83% were white. In comparison, the total NROTC population at Virginia Tech is 86% male and 14% female and 90% white. Although the sample had a slightly higher representation of females and minorities than the total population, this sample is overall representative of the entire NROTC unit. Furthermore, the sample is almost a precise representation of the sex and racial makeup of active-duty Navy officers, which are 83% male, 17% female, and 79% white. **See Table 3**.

One participant received a medical waiver for the entire PFA, and another individual received a waiver for the 1.5-mile run. Midshipmen's mean PRT score was 80.7 with a maximum possible score of 100, and a score of 45 required to pass the PFA. Scores ranged from 42 to 100, with only one individual scoring below 45 and thereby failing the PFA. The mean BMI for midshipmen was 23.7, falling with the normal weight range. Sixty-nine percent of midshipmen were classified as normal weight by BMI (18.5-24.9 kg/m^2). Twenty-five percent were classified as overweight (25.0-30.0 kg/m^2), whereas only 4% were considered obese (≥30.0 kg/m^2) and 2% were underweight (≤18.4 kg/m^2). See **Tables 4 and 5**.

Table 3. Reach and Representativeness of Sample by Sex and Race

Demographic Characteristics	Total Sample n=102	NROTC Virginia Tech Unit N= 202	Active-duty Navy Officers N=54,114
Male	82%	86%	83%
Female	18%	14%	17%
White	83%	90%	79%
Asian	7%	7%	5%
Other Minorities	10%	3%	16%

Table 4. Mean BMI and Physical Readiness Test (PRT) Scores of Midshipmen

	n	Range	Minimum	Maximum	Mean	Std. Deviation
BMI (kg/m^2)	101	14.8	18.4	33.2	23.7	2.7
Curl-up Score (max= 100)	101	50.0	50.0	100.0	82.4	15.9
Push-up Score (max=100)	101	70.0	30.0	100.0	83.3	16.3
Run Score (max=100)	100	55.0	45.0	100.0	75.9	13.3
Total Score (max= 100)	101	58.0	42.0	100.0	80.6	13.0

Table 5. Midshipmen Weight Classification by BMI

Weight Status	Frequency (n=101)	Percent
Underweight	2	2 %
Normal	70	69 %
Overweight	25	25 %
Obese	4	4 %

Most midshipmen either agreed or strongly agreed with the statement, "I consider myself an athlete" (**Figure 1)**, and the majority rated their nutrition knowledge level moderately as "some knowledge" (**Figure 2)**. The most common source of information cited by participants was the internet, followed by family and friends. Only ten of the midshipmen reported looking to Registered Dietitian Nutritionists or student nutrition counselors, while approximately twice as many participants reported receiving nutrition information from their chain of command or social media (**Figure 3)**.

Figure 1. Athlete Identity: How strongly do you agree with the statement "I consider myself an athlete"?

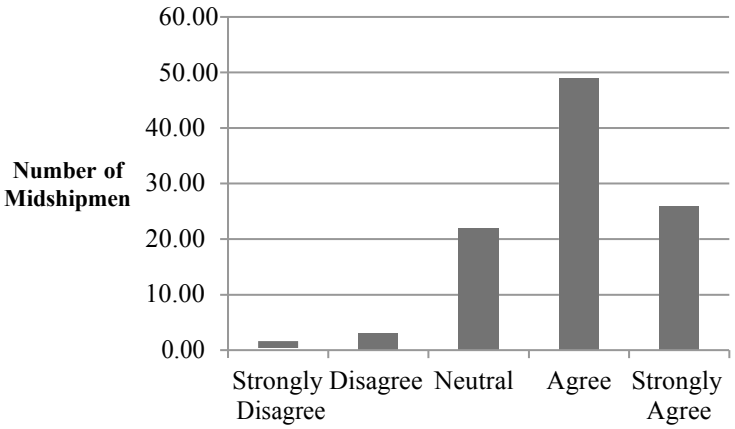


Figure 2. Self-Rated Nutrition Knowledge

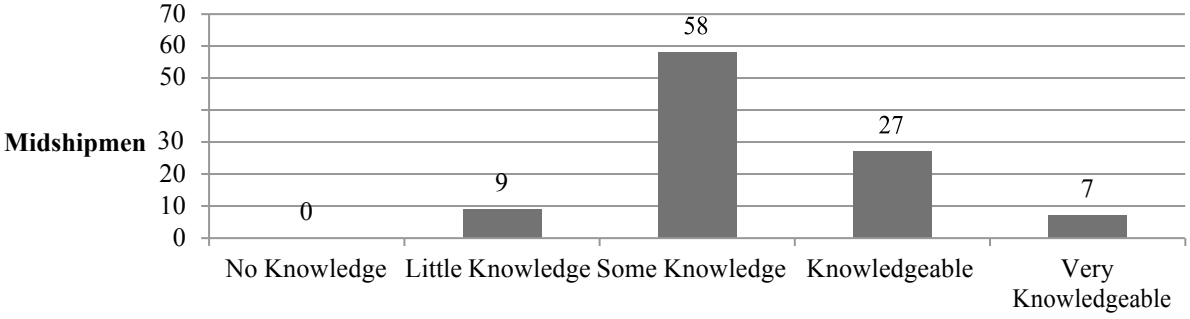
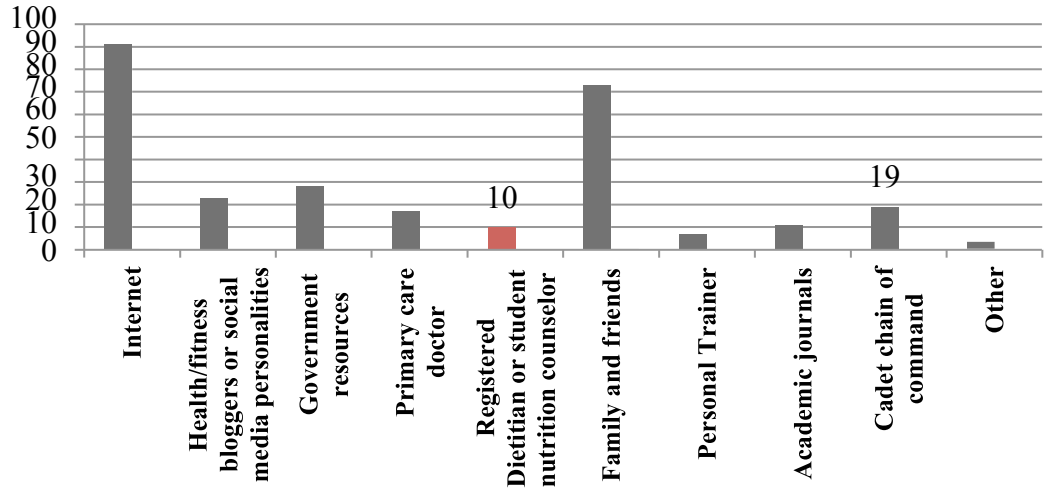


Figure 3. Reported Sources of Nutrition Information for NROTC Midshipmen



Total Sports Nutrition Knowledge

Participants scored an average of 51% on the 86-item M-NSKQ. There were no significant differences in the mean M-NSKQ score across grade level, sex, or race. Additionally, there were no significant differences when participants were grouped for self-rated nutrition knowledge, athlete identity, or nutrition counseling history. The detailed report of responses for individual questions is included as **Appendix F**. See **Table 6** for the total and subsection M-NSKQ scores.

Table 6. M-NSKQ Scores of NROTC Midshipmen

M-NSKQ Sections	n	Min	Max	Mean	Std. Deviation	Mean % Correct
Total Nutrition Knowledge Score (86 points)	93	8	77	44.0	11.0	51
Weight Management Score (12 points)	100	2	12	7.3	2.0	61
Macronutrients Score (27 points)	99	1	24	13.9	4.1	51
Micronutrients Score (16 points)	100	0	16	8.5	3.3	53
Hydration Score (4 points)	102	0	4	1.8	1.0	45
Nutrient Timing Score (7 points)	101	0	7	3.4	1.6	49
Supplementation Score (13 points)	102	0	10	4.9	2.2	38
Alcohol Score (7 points)	101	0	7	4.1	1.6	59

Relationship between M-NSKQ Scores and PFA Scores

M-NSKQ scores, including the total score and all subscores were analyzed against BMI, total Physical Readiness scores, push-up scores, curl-up scores, and run scores. There were no statistically significant correlations found between participants' M-NSKQ scores and of the measures from the standardized U.S. Navy PFA. Additionally, there were no relationships between specific nutrition practices and PFA scores. Thus, the midshipmen's nutrition knowledge and reported nutrition practices were evaluated in an exploratory manner to provide a detailed report of nutritional knowledge and practice deficits. The following sections provide details from the seven subsections of the M-NSKQ.

Sports Nutrition Knowledge: Weight Management

Midshipmen scored the highest in the weight management subsection with a mean score of 61%. The majority of respondents were able to identify general recommendations for weight management, with 89% correctly answering that the best way for an athlete to ensure they are meeting their energy needs is to "plan their diet according to their age, sex, body size and physical activity level". However, midshipmen had more difficulty when the questions addressed specific meal examples or recommendations regarding macronutrients in weight management. Less than 50% of midshipmen knew a diet for weight loss should target reduction in total calorie intake, rather than placing severe restrictions on a specific macronutrient. Twenty percent of midshipmen indicated that carbohydrate intake should be reduced to less than 50 grams per day, when expert recommendation suggest 5-7 grams of carbohydrate per kilogram of bodyweight for athletes engaging in moderate-intensity exercise programs. Twenty-two percent thought that fat should be restricted to less than 20 grams per day for weight loss, when recommendations suggest athletes obtain at least 20% of their calories from fat. [23] Similarly, only 32% of respondents were able to identify that the statement "Stop eating carbohydrate-containing foods after 4 PM" was an ineffective strategy for weight loss. When asked to identify an appropriate meal for an athlete trying to gain weight, most respondents answered "a large piece of grilled chicken with a side salad", an option that omitted any significant source of carbohydrate, instead of the correct answer, "Pasta with lean ground beef and marinara sauce, plus a dessert of fruit, yogurt and nuts".

Sports Nutrition Knowledge: Macronutrients

The mean score for the macronutrient subsection was 52% on 27 items regarding the roles, sources, and needs for each macronutrient. Nearly all respondents (82%) knew that fat is used to

make cell membranes and molecules and involved in immune function, and 57% knew that protein is not the primary source of energy used by muscles during exercise. However, only 40% of midshipmen correctly answered that fat is used as the primary substrate during low-intensity exercise, and over 50% of respondents mistakenly believed that carbohydrates are the most energy dense macronutrient.

Over 75% of respondents were able to identify quinoa as a significant source of carbohydrates, but less than half correctly identified a banana as a carbohydrate source. At least 70% of midshipmen knew that avocado and mixed nuts are fat sources, but less than half (45%) knew that a buttermilk biscuit contains a significant amount of fat. Of all questions regarding sources of macronutrients, the most participants (85%) were able to correctly identify kidney beans as a protein source, but, in comparison, only 54% of respondents knew that a cup of kidney beans is also a significant source of carbohydrates. More than half (58%) of midshipmen mistakenly believed that almond milk is high in protein, while only 50% knew that cottage cheese is a good source of protein. Additionally, 87% of participants were unable to identify green peas as a protein source.

When asked about carbohydrate needs of an endurance athlete, only 30% of respondents correctly answered, "5-8 g carbohydrate per kg body weight per day (e.g. 340-540 g for a 150 lb athlete)". Instead "15-25% of total daily calorie intake" was the most frequently chosen answer, which would amount to severe carbohydrate restriction. In comparison, 49% of respondents correctly estimated daily protein needs, and there was a nearly equal split of incorrect responses (20% and 18%) between underestimating and overestimating protein needs.

Sports Nutrition Knowledge: Micronutrients

The mean score in the micronutrient subsection was 53%. A least one third of respondents answered "not sure" to eight of 16 items. Participants were most knowledgeable on the roles of micronutrients; eighty-three percent correctly answered questions regarding the role of potassium in electrolyte balance and the role calcium and Vitamin D in injury prevention. Over half of midshipmen were able to correctly answer questions concerning the role of antioxidants in muscle recovery and Thiamin in energy production during aerobic exercise. In contrast, only 26% of respondents knew that the statement "The main role of iron is the conversion of food into usable energy" was false.

Despite understanding the roles of Vitamin D and potassium, only 38% of midshipmen knew that baked potatoes are high in potassium, and that salmon is a good source of Vitamin D. In contrast, the majority of participants were able to identify food sources of antioxidants and correctly disagreed with the statement "milk yogurt, and cheese are the best sources of iron". There were no significant correlations between knowledge of micronutrient roles and food sources of micronutrients.

The midshipmen were most informed on micronutrient needs (a subsection of the micronutrient section), with at least a 60% correct response rate on four of five items. Most participants were aware that sweat rate may influence magnesium needs, menstruating females have higher iron needs, sunlight exposure influences Vitamin D needs, and that vitamins and minerals do not provide the body with calories. However, 60% of respondents incorrectly agreed "a physically fit person eating a nutritionally adequate diet can improve their performance by eating more vitamins and minerals".

Sports Nutrition Knowledge: Hydration

The mean hydration subscore was 45% across four items. When asked to identify the current recommendations for fluid intake during exercise, less than one third of participants knew that athletes should hydrate according to changes in body weight, while 25% incorrectly answered "avoid sports drinks to limit added sugar consumption". Similarly, more than half of participants thought a low- calorie or sugar-free sports drink was the most appropriate option for hydration during intense exercise lasting over an hour.

Sports Nutrition Knowledge: Nutrient Timing

The mean nutrient timing subscore was 49% across seven items. Responses in this section mirrored those from hydration in terms of the tendency to evade carbohydrate-containing beverages during exercise. On all three questions about carbohydrate consumption during exercise, at least one third of participants answered "not sure". However, when given a multiple choice question asking participants to pick the most appropriate snack for high-intensity exercise lasting 90 minutes, the correct answer, "a ripe banana", was the most frequently selected answer choice. Similarly, respondents most frequently answered correctly with "fluids and carbohydrate" when asked about general pre- and during workout fueling recommendations. However, over one third of respondents were misinformed on the same matter; answering "a handful of nuts" as appropriate snack during high-intensity exercise, and that foods high in "fluids and protein" should be consumed during exercise.

Sports Nutrition Knowledge: Supplementation

Midshipmen scored the lowest on the supplementation questions, with a mean score of 38%. The responses indicated a tendency to favor the consumption of supplements while experts recommend the conservative use of supplements and the "food first" approach. [27] Across four

items assessing the needs of micronutrient (Vitamin C, B Vitamins, Multivitamins, and Iron) supplements, no question received more than a 30% correct response rate. Of these, participants most frequently answered incorrectly when presented with the statement, "Vitamin C should be routinely supplemented by athletes", to which more than half of midshipmen incorrectly agreed.

Findings on knowledge regarding the benefits of performance-enhancing produced similar results to responses regarding vitamins and minerals. However, more participants answered "not sure" than when asked about vitamins and minerals. Only 28%, 6%, and 26% of midshipmen correctly answered questions on the proposed benefits of creatine, beetroot (nitrate), and beta-alanine supplements, respectively, and "not sure" was selected most frequently in all cases.

Eight-two percent of participants knew that supplement labels may contain false or misleading information, and similarly 72% knew that the purity and safety of supplements are not tested before sale. However, less than half of participants correctly disagreed with the statement "the purity and safety of supplements sold on U.S. military bases are tested before sale".

Sports Nutrition Knowledge: Alcohol

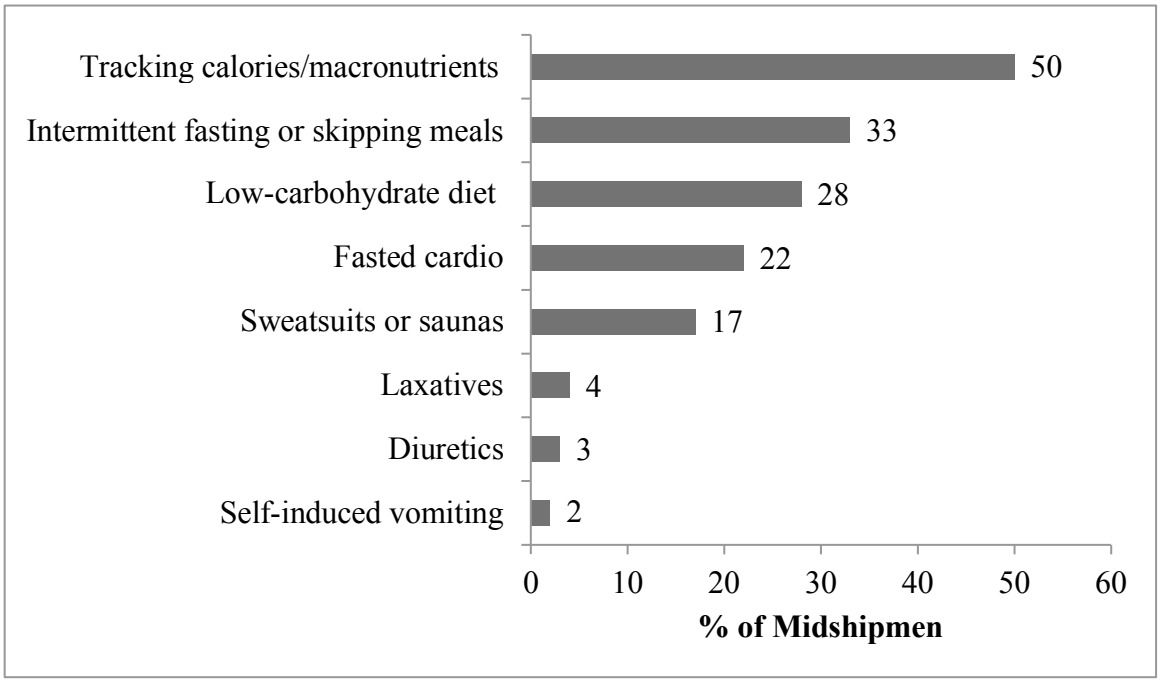
Midshipmen scored an average of 58% on the alcohol subsection. Most respondents correctly answered questions about the negative impacts of excessive alcohol consumption on injury risk, hormonal health, and vitamin and mineral deficiencies. Additionally, the majority was able to correctly define binge drinking. However, most respondents overestimated the number of standard drinks that can be consumed on a daily basis without increasing the risk of alcohol-related harm.

Nutrition Practices

Use of Weight Management Strategies

Seventy percent of midshipmen reported having used at least one of the listed weight management strategies. Tracking of calories or macronutrients was the most commonly used weight management strategy, with 49% of midshipmen reporting the practice. This was followed by intermittent fasting or skipping meals, reported by 32% of respondents, low-carbohydrate diets (such as Ketogenic, Paleo, Whole30, Atkins, or Zone), reported by 27%, fasted cardio, reported by 22% and sweatsuits/saunas, reported by 17%. In contrast, less than 4% of midshipmen reported the use of laxatives, diuretics or self-induced vomiting. **Figure 4** details the number of respondents that reported using each strategy.

Figure 4: Weight Management Strategies Reported by NROTC Midshipmen

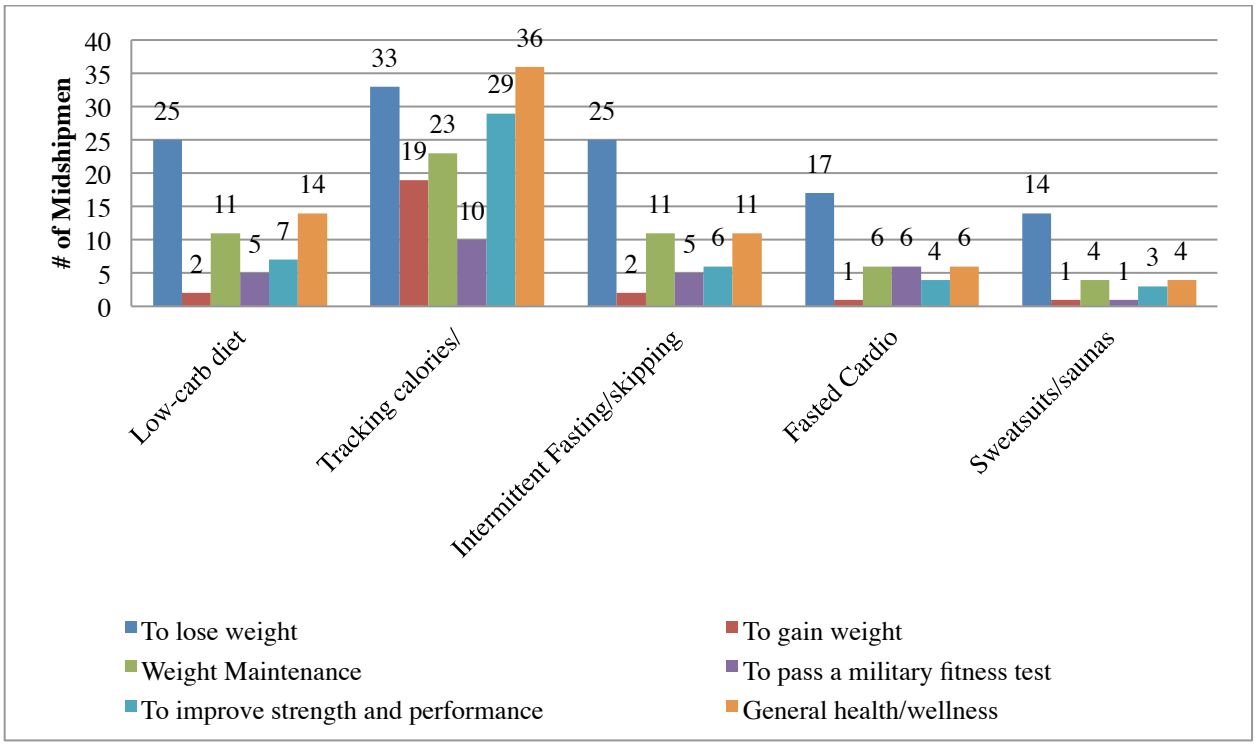


Those who reported using a weight management strategy were given a multiple response format follow-up question why they used each strategy: to lose weight, to gain weight, for

weight maintenance, to pass a military fitness test, to improve strength and performance, and/or for general health/wellness. Weight loss was most frequently cited as the reason for use across all categories except tracking of calories or macronutrients. The majority of those tracking their food intake did so for "general health and wellness". Additionally, tracking was the only strategy commonly used with the intention of gain weight and/or improving strength and performance. However, tracking food intake was still used more often for weight loss than for weight gain, and it was the most commonly used strategy for passing military fitness tests.

More than half of midshipmen indicated weight loss as a reason for using at least one given strategy, but only 30% of those individuals simultaneously indicated the desire to pass a military fitness test. When accounting for multiple responses, 22.5% of midshipmen reported passing a military fitness test as their reasoning for practicing at least one weight management strategy. Frequencies of the reported reasons for use of common weight management strategies are detailed in **Figure 5.**

Figure 5. Reasons for Using Weight Management Strategies

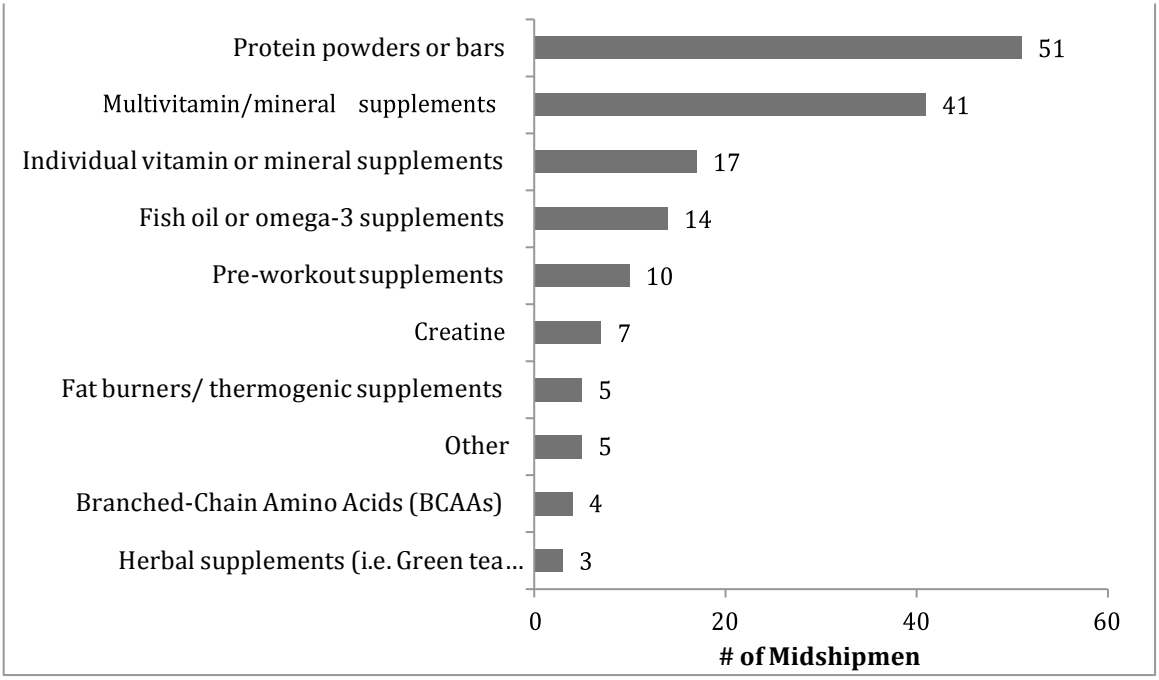


Supplement Use

Seventy-seven percent of participants reported using at least one dietary supplement. Of those, 59% indicated that they did not check for third-party testing certification when purchasing supplements. Protein powders or bars were the most commonly used supplement, with exactly 50% of the sample reporting their use. This was followed by multivitamins or mineral supplements, used by 40% of respondents. Bodybuilding supplements other than protein were used less frequently. Less than 10% of participants used pre-workout, creatine, and branched-

chain amino acid supplements, and none of the participants reported using "testosterone boosters". **Figure 6** details the prevalence of use for different types of supplements.

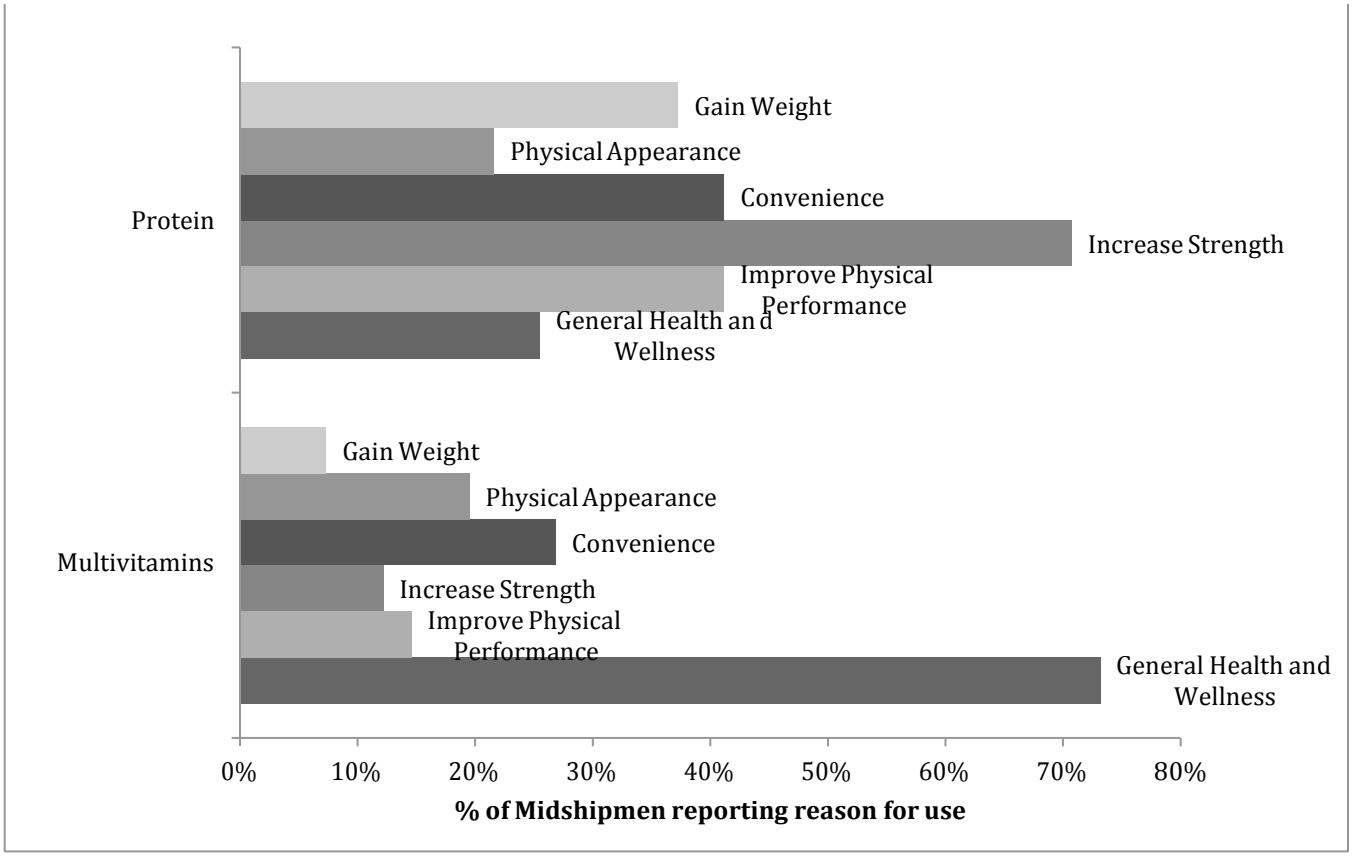
Figure 6. Types of Supplements Used by NROTC Midshipmen



"General health and wellness" was the most frequently cited reason for use of supplements, overall. However, reasons for use were notably different for body building supplements including protein, pre-workout, and creatine, than for vitamins and mineral supplements. Seventy-three percent of multivitamin or mineral users and 59% of individual vitamin or mineral users selected general health and wellness as their reason for use, while physical performance and weight- related intentions were rarely cited. After general health and wellness, convenience was the second most cited reason, selected by 27% of users. Conversely, only 25% of protein supplement users selected general health and wellness, while "increase strength" was selected more than twice as often, by 57% of users. Desire to gain weight, improve physical performance, and convenience were also cited more often than general health and wellness by protein supplement

users. Similarly pre-workout and creatine supplements were most commonly used to increase strength or improve physical performance. **Figure 7** depicts the comparison in motivations to use the two most commonly reported supplements, multivitamins/minerals and protein.

Figure 7. Reasons for Multivitamin and Protein Supplement Use



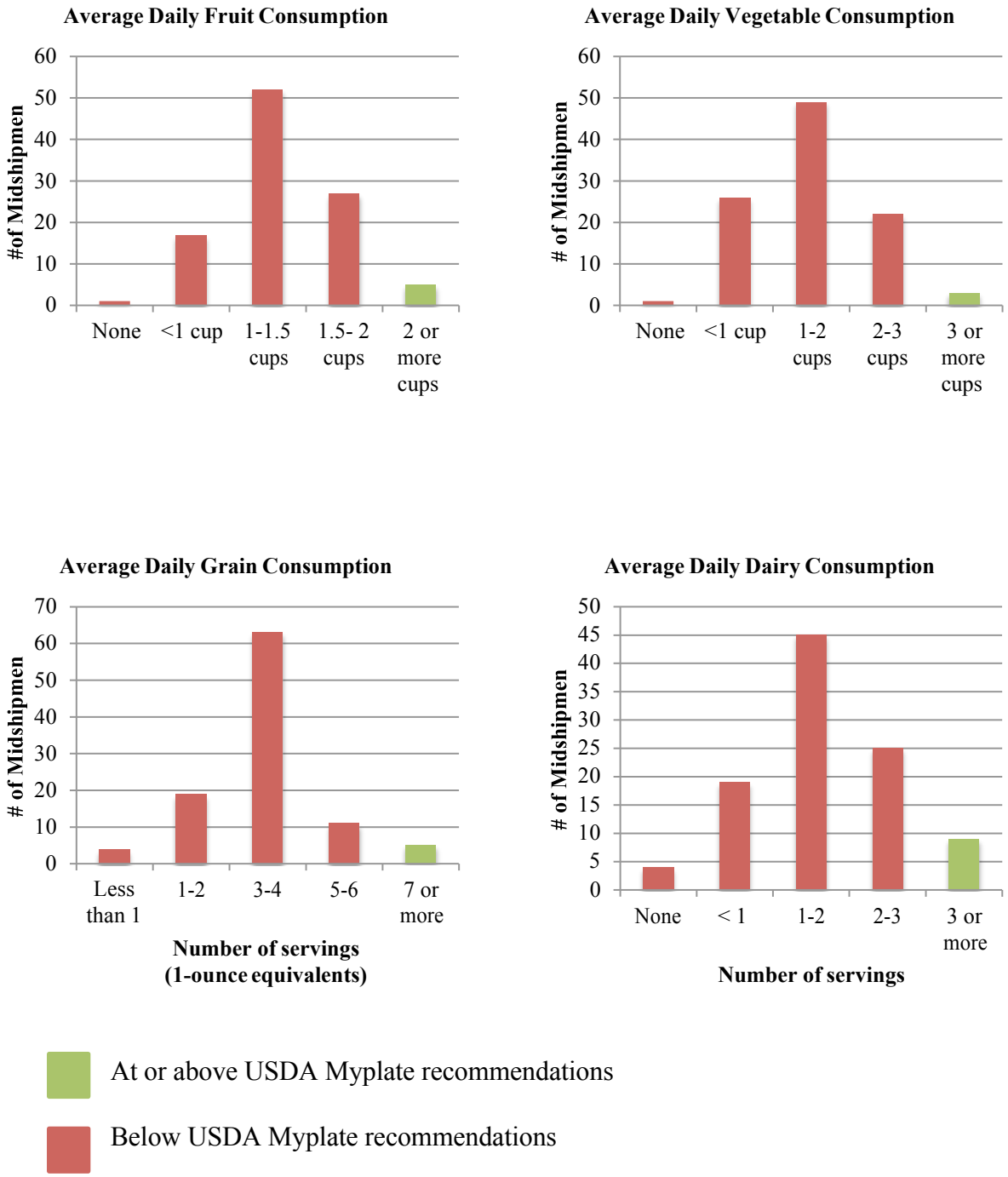
Dietary Patterns

Midshipmen were asked four questions to assess their intake of fruits, vegetables, grains, and dairy based on the USDA MyPlate guidelines. Protein intake was assessed more specifically in the sports nutrition practices portion of the questionnaire. The median age of the sample was 20 years, the mean weight was 168 pounds for men and 144 pounds for women, and the mean height was 5'10" for men and 5'6" for women. Given this information, for the majority of participants, the USDA MyPlate guidelines recommend at least 2 cups of fruit, 3 cups of

vegetables, 7 ounce-equivalents of grains, and 3 cups of dairy. **Figure 8** depicts the participants' self-reported average daily intake of fruit, vegetables, grains, and dairy by the frequency of respondents in each consumption category. The bar in green represents an intake level at or above the recommendations.

Only 3% of midshipmen reported meeting the daily recommendations for vegetables, 4% for grains and fruit, and 9% for dairy. The majority reported eating 4 or less ounce-equivalents of grains, less than 1.5 cups of fruit, less than 2 cups of vegetables, and less than 2 servings of dairy.

Figure 8. Fruit, Vegetable, Grain, and Dairy Consumption Related to USDA MyPlate Guidelines



Sports Nutrition Practices

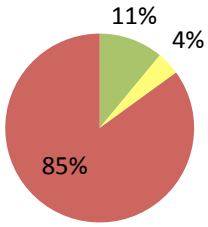
Participants were presented with 5-point Likert-scale questions including a variety of statements regarding specific fueling practices. Responses were grouped into three categories, “always or most of the time”, “sometimes”, and “rarely or never” for analysis. Midshipmen responded most favorably for statements on post-workout meal timing and post-workout protein intake. Seventy-two percent and 69%, respectively, reported eating within an hour of working out and eating 15-40 grams of protein after a workout “always or most of the time”. However, midshipmen appeared to be less likely to fuel properly with carbohydrates post-workout, as only 37% reported making a point to eat foods high in carbohydrate after exercising.

Overall, participants responded less favorably to statements regarding hydration and pre-workout fueling. Eight-five percent of midshipmen reported rarely or never weighing themselves to determine their fluid needs, while approximately 75% did not frequently make a point to consume sports drinks during long, intense workouts, or replenish with electrolytes after working out. Additionally, only 21% of respondents reported eating before working out always or most of the time, and 0% reported always eating a carbohydrate-rich snack within an hour of beginning exercise.

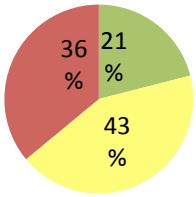
Figure 9. Frequency of Proper Fueling Practices Among Midshipmen

Always/ Most of the Time
Sometimes
Rarely/ Never

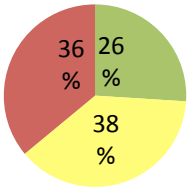
"I weigh myself before and after exercise to determine how much water I need to drink."



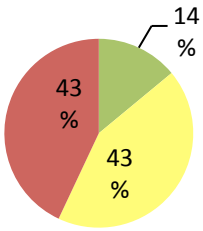
"I eat before working out"



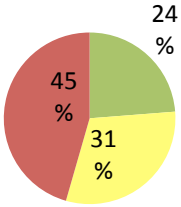
"I drink a sports drink or eat salty foods after an intense workout."



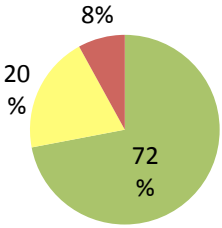
*"I eat a carbohydrate-rich snack within 1 hour of beginning a workout."(*0% answered always)*



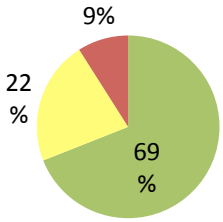
"I consume carbohydrates (sports drinks, fruit, energy gels) during intense workouts lasting more than 75 minutes."



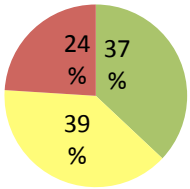
"I eat within an hour of finishing a workout."



*"I consume 15-40 grams of protein after working out."(*0% answered never)*



"I make a point to eat foods high in carbohydrate after working out (e.g., rice, pasta, oatmeal, quinoa, cereal, bread, potatoes, beans, fruit)."



Discussion

The aim of this study was to explore the gaps in knowledge and common nutrition practices among Naval ROTC midshipmen. Although there is no defined level of what is considered "adequate" nutrition knowledge, midshipmen are unique from athletes because of the nature of their career path. Based on the demographic makeup of the present sample, they are representative of the NROTC unit at Virginia Tech and active-duty Navy officers, and thus their responses may be generalizable to a broader population of active-duty officers. As future Navy officers, they may be in the position to influence to food-related beliefs and practices of their subordinates as well as the built environment in military communities. [28] Military communities are directly connected to the civilian population through the military family. Fifty-two percent of active-duty Navy sailors have civilian dependents (children and/or spouses) [37], and thus the military community is not isolated, but rather a key subset of the greater American population.

It is well understood that behavior is a product of individual, interpersonal, community, institutional, and societal factors. [35] The nutrition knowledge and food beliefs of military officers may impact the individuals' eating behavior, but furthermore may carry over to their colleagues, families, and surrounding communities. The influence of military personnel may be heightened if they are perceived by the public as a physically fit population. Due to weight stigma, nutrition advice is often received more positively from those that appear physically healthy. [38] This influence may be used positively to impact the nutrition knowledge, eating behaviors, and health outcomes of communities. However, if the discourse surrounding nutrition is grounded in misconceptions, the influence of military officers has equal potential to be negative.

Midshipmen's responses to the M-NSKQ and nutrition practices questionnaire highlights pertinent misconceptions and gaps in knowledge that should be addressed before this population is competent to exert influence regarding nutrition.

The majority of existing studies examining nutrition knowledge in athletes report scores ranging from 50-70% correct 29, which is similar to the present findings. However, the variability in instrumentation makes it difficult to draw accurate comparisons. In the validation of the original Nutrition for Sport Knowledge Questionnaire (NSKQ), by which the present questionnaire was modeled, Trakman et al., found significant differences in the NSKQ scores for athletes who had previous nutrition education versus those who had not; athletes with previous education scored an average of 65%, while athletes without nutrition education scored a mean of 52% on the 89-item questionnaire. 11 Similarly, midshipmen scored an average of 51% on the 86- item Modified Nutrition for Sports Knowledge Questionnaire (M-NSKQ). This indicates that midshipmen may have a similar level of nutrition knowledge to athletes without previous nutrition education.

Although the nutrition knowledge scores may not be comparable across different questionnaires, common gaps in knowledge are apparent across athlete populations and the present sample. Athletes tend to underestimate their carbohydrate needs, misunderstand the importance of carbohydrates in performance, and are susceptible to low-carbohydrate diet fads despite the importance of carbohydrates in performance. 13,30 Results in the weight management, macronutrient, and hydration sections of the M-NSKQ suggest similar attitudes among midshipmen. Midshipmen tended to answer in favor of answers that promoted carbohydrate restriction and underestimated carbohydrate needs. Additionally, midshipmen tended to denounce the use of carbohydrate-containing beverages during exercise, despite the well-understood benefit of consuming carbohydrates during long, intense workouts. These trends carried over to responses on the nutrition practices portion of the survey as well. In general, respondents reported under-fueling with carbohydrates before, during, and after exercise. This was mirrored by low reported intakes of grains, fruits, and vegetables, as well as the relatively high prevalence of low-carbohydrate diets.

Compared to a sample of athletes where 18% of females and 6% of males reported having ever practiced a low-carbohydrate diet, 27% of midshipmen reported doing so, despite being a mostly male sample. [30] Unlike with athletes, there was no significant difference in low-carbohydrate dieting between males and females. This suggests that military populations may be more susceptible to fad diets than athlete populations, and supports previous research that military personnel are at a high-risk for eating disorders. [15]

Seventy percent of midshipmen reported using at least one of the mentioned weight management strategies: low-carbohydrate diets, tracking of calories or macronutrients, intermittent fasting or skipping meals, sweatsuits and/or saunas, laxatives, diuretics, fasted cardio, and self-induced vomiting. Except for tracking of calories and macronutrients, all of the above strategies should be considered inappropriate, restrictive eating practices. In total, 51% of midshipmen reported practicing at least one restrictive weight management strategy. Although eating disorders were not specifically evaluated, this data is comparable to the 41% prevalence of unspecified eating disorders found in an active-duty Navy sample.

Tracking of calories and/or macronutrients is a controversial weight management strategy because it has the capacity to be a useful tool, but may also act as a method of restrictive eating for those prone to disordered eating. 32,33 Computerized food tracking applications like MyFitnessPal allow users to see the macronutrient composition of their meals, and thus may also act as an educational tool, improving users' ability to understand food sources of macronutrients. However, in this case, those who reported tracking also were not more likely to correctly answer questions regarding food sources of macronutrients. Tracking food intake also did not produce any difference in nutrition knowledge scores or reported positive fueling practices.

In addition to the high prevalence of weight management practices, there was also a high rate of reported supplement use with 77% of midshipmen reporting using at least one supplement. This was notably higher than the 50% prevalence of supplement use among ROTC cadets reported by Valentine et al. [34], but comparable to the 73% rate of supplement use seen in a recent sample of active-duty Navy and Marine Corps personnel. [19] Although a relatively low number of midshipmen reported use of high-risk supplements (i.e., pre-workout or "thermogenic" supplements) compared to active duty military personnel [19], all midshipmen are part of the Corps of Cadets and are required to reside on campus, thus limiting their access to supplements. The majority of midshipmen were either unsure or mistakenly believed that the purity and safety of supplements sold on military bases are tested before sale. Their lack of knowledge regarding the safety of supplements suggests that they may be susceptible to increasing their use of high-risk supplements as they move forward in their military career and are faced with a high level of accessibility to supplements on military bases.

More importantly, the average dietary intake and fueling practices of midshipmen helped identify several areas of improvement that should be targeted before turning to supplement use. Forty percent reported using multivitamin supplements, most commonly for the purpose of "general health and wellness", yet less than 10% of midshipmen met the daily recommendations for fruit, vegetable, grain, and dairy. Similarly, 50% of midshipmen used protein supplements, commonly citing the desire to "increase strength", "gain weight", and "improve physical performance", yet the majority of respondents also indicated that they do not frequently eat before working out in general, and do not make a point to fuel with carbohydrates before, during, or after working out.

Limitations of this study include the lack of comprehensive dietary assessment methods, such as multiple 24-hour dietary recalls to assess overall dietary quality and dietary intake. The availability of this quantitative data would allow for more direct comparisons between dietary behaviors and nutritional knowledge. A strength of this study was the reach and representativeness of this sample. Over half of the Virginia Tech NROTC population was reached in this investigation. Furthermore, the sample was representative of both the immediate Virginia Tech NROTC population and the active-duty Navy officer population; thus, this data is likely generalizable for larger scale interventions.

These results highlight the need to improve both the nutrition knowledge level and dietary practices of NROTC midshipmen. The examination of frequently missed questions from the M-NSKQ showed that misconceptions regarding carbohydrate needs and appropriate weight management practices appear to carry over into midshipmen's nutrition practices. The low level of nutrition knowledge in this population, combined with the low level of adherence to USDA MyPlate recommendations suggest initial nutrition education with this population should address basic concepts of nutrition related to general wellness as a precedent to introducing performance nutrition concepts. Given the high level of athlete identity and reported performance-related motivations for supplement use, it may be helpful to frame basic nutrition recommendations in terms of their role in improving performance—for instance promoting the consumption of fruits and vegetables by highlighting their role in balancing exercise-induced inflammation. In addition to informing the development of tailored nutrition education programs, an athlete-specific nutrition knowledge questionnaire will allow for the use of nutrition knowledge as an outcome measure. Evaluation of program outcomes is crucial in substantiating the need for nutrition education.

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Chapter 3: Conclusion and Future Directions

Nutrition knowledge is one of the few modifiable factors influencing dietary behaviors. Improving nutrition knowledge through nutrition education or counseling interventions may produce positive changes in diet quality [1], given that the educational intervention is appropriately tailored to the population as determined by a needs assessment. Furthermore, an intervention targeting knowledge alone may not impact food choices if intentions, attitudes, social factors, and environmental factors are not simultaneously addressed. [2]

Currently, nutrition education is not universally incorporated in military training as a means of enhancing physical performance through improved dietary intake. Nutrition education is used in the U.S. Navy only as a disciplinary measure for those who fail to pass their Physical Fitness Assessment (PFA). Upon failing the PFA, sailors are enrolled in the "Shipshape" Weight Management Program, which is taught by certified facilitators, rather than Registered Dietitian Nutritionists (RDN). The only reported outcome measure for the Shipshape program is the PFA pass rate within six months of completion. [3]

Similarly, despite the growth of collegiate and professional sports dietetics in recent years, there is limited documentation of how these efforts are developed and evaluated. [4] As the primary target of an educational intervention, nutrition knowledge should be assessed in both the design and evaluation process. The Modified Nutrition for Sport Knowledge Questionnaire (M-NSKQ) provides a comprehensive tool to assess nutrition knowledge in athlete populations. While the total M-NSKQ score and subsection scores are appropriate for quantifying sports nutrition knowledge in program evaluation, the numeric scores alone cannot inform program development. Detailed descriptive analyses of responses to individual items on the M-NSKQ, as provided in the present study, are necessary for discerning knowledge gaps in a given population.

This tool may be appropriate for use with competitive athletes and military populations, but more research should be completed to evaluate the validity of this tool within other populations.

Aside from the understanding that experts should score higher than other populations, there are no defined levels of "high" or "low" nutrition knowledge, largely due to the lack of consistency in instrumentation in previous studies. An adequate level of nutrition knowledge may also vary across populations. For instance, high-ranking military officers should possess a higher level of knowledge than their subordinates, whereas strength and conditioning coaches may require a higher level of knowledge than their athletes. Use of consistent instrumentation is needed to produce these comparisons across populations and determine benchmark levels of sports nutrition knowledge.

Currently, all items are equally weighted on the M-NSKQ. Revisions to the scoring algorithm may be necessary to differentiate between declarative knowledge of basic concepts, procedural knowledge (or knowledge of application), and expert-level knowledge. Additionally, although all items on the M-NSKQ are relevant to athletes, some items assess concepts related to general wellness, while others are performance- specific. For future use, it may be appropriate to distinguish between these categories.

Next, a sports nutrition education intervention should evaluate food intake as a behavioral outcome, however, there are limited tools available to assess sports-specific eating behaviors. Typically, Likert-style questions are used and responses are analyzed on an individual basis, but there is no method for quantifying or scoring nutrition practices. Other methods, such as food frequency questionnaires or the Healthy Eating Index are not able to adequately assess nutrition practices in athletic populations as they do not account for timing of meals and macronutrients

around workouts, workout intensity, or athlete-specific nutritional needs. Future efforts should be made to determine a standard methodology for quantifying nutrition practices in athletes.

Lastly, nutrition education interventions should be designed and evaluated in terms of their ability to impact secondary outcomes of interest to the target population. Metabolic measures and weight status are often used as outcomes for nutritional interventions in unhealthy, overweight populations, but these measures have less relevancy in sports nutrition programs with healthy athletes, and are more applicable to long-term studies. Instead, physical performance measures, sick days, and rates of injury are more appropriate in evaluating the efficacy of an educational intervention with athletes in the short term. Although there was no relationship between M-NSKQ scores and PFA scores in the present study, this was only a preliminary evaluation and did not assess individual changes in fitness level through an intervention. Recent criticisms regarding the validity of the PFA suggest that the test itself may need revision before it can be accurately used as an outcome measure.

Findings from the present study highlight several trends within the Naval Reserve Officer Training Corps (NROTC) population. Midshipmen struggle to meet basic MyPlate recommendations, independent of nutrient timing and sports nutrition considerations, and have a low baseline level of knowledge. General nutrition recommendations are commonly given in term of food groups, while sports specific recommendations are often provided in terms of macronutrients. Based on the findings, midshipmen would not be equipped to comprehend advanced sports nutrition recommendations initially. Interventions should be delivered in step-wise modules, focusing first on general health and wellness, while introducing macronutrients, before moving into more advanced concepts. Exposing midshipmen to this information in the

early stages of their career will equip them with additional tools to be effective military leaders before they commission. Next steps should include the development and delivery of a pilot nutrition education intervention as an experiential learning opportunity and partnership between Virginia Tech's Didactic Program in Dietetics and NROTC. This intervention should be developed with the intent of disseminating the program to other NROTC units and officer training programs.

References

1. Parmenter K, Wardle J. Development of a general nutrition knowledge questionnaire for adults. *Eur J Clin Nutr.* 1999;53(4):298-308.
2. Spahn JM, Reeves RS, Keim KS, et al. State of the Evidence Regarding Behavior Change Theories and Strategies in Nutrition Counseling to Facilitate Health and Food Behavior Change. *Journal of the American Dietetic Association.* 2010;110(6):879-891.
3. United States Navy. Guide 14: Nutrition Resource Guide. 2016.
4. Parks RB, Helwig D, Dettmann J, et al. Developing a Performance Nutrition Curriculum for Collegiate Athletics. *Journal of Nutrition Education and Behavior.* 2016;48(6):419-424.e41

Appendix A. IRB Approval Letter

Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE: February 1, 2018

TO: Valisa Ellen Hedrick, Alexa Brooks, Chet M Fearon

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires January 29, 2021)

PROTOCOL TITLE: Exploration of Sports Nutrition Knowledge, Nutrition Practices and Physical Performance on Standardized U.S. Navy Physical Fitness Asssessments in an ROTC Population

IRB NUMBER: **17-1121**

Effective February 1, 2018, the Virginia Tech Institution Review Board (IRB) approved the New Application request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

http://www.irb.vt.edu/pages/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As:	**Expedited, under 45 CFR 46.110 category(ies) 5,7**
Protocol Approval Date:	**February 1, 2018**
Protocol Expiration Date:	**January 31, 2019**
Continuing Review Due Date*:	**January 17, 2019**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Date*	OSP Number	Sponsor	Grant Comparison Conducted?

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

Appendix B. Modifications to Original Nutrition for Sport Knowledge Questionnaire (NSKQ)

Original Question #	Original Question/ Statement/ Answer Choice	Modified Question/ Statement/ Answer Choice	Rationale for change
1.3- 1 2.5- 2	"canola spread (polyunsaturated margarine)"	"canola-oil spread or margarine"	To increase recognition and reduce use of complex/scientific wording
1.3-3	"Exchange yogurts, muesli/granola bars and fruit snacks for protein bars and shakes"	"Exchange yogurt, granola bars, and fruit for protein bars and shakes"	"Muesli" was removed to reflect lack of cultural familiarity; "snacks" was removed to avoid confusion with fresh fruit and the popular American food product "Fruit Snacks".
1.3-4	"Choose lower glycemic index (GI) carbohydrates"	"Split up protein intake evenly throughout the day"	No questions evaluate participants' understanding of glycemic index; protein timing is considered an important factor in maintaining muscle mass while losing weight. [110]
1.5	First answer choice: "Plan their diet according to their age, gender, body size, sport and training program"	"Plan their diet according to their age, gender, body size and physical activity level"	Wording changed to be generalizable to non-sport specific athletes, such as ROTC cadets or military personnel.
1.5	Second answer choice: "Eat to appetite following their natural hunger and fullness signals"	"Eat the same amount of calories that they expend during training"	Listening to appetite and eating intuitively may be an appropriate weight management strategy for athletes and should not be denounced.
1.5	Fourth answer choice: "choose foods that are high in carbohydrate"	"Choose high-protein, low carbohydrate	It may be appropriate for athletes to choose high-carbohydrate foods to meet

		meals”	their energy needs; answer choice was changed to reflect the popular low-carbohydrate trend and its potential effect on athletes. [34]
1.6 1.7	“mincemeat” and “vegetable sauce”	“ground beef” and “marinara sauce”	Wording changed for cultural appropriateness
1.7	Second answer choice: “A pure whey protein isolate (WPI) shake made on water”	“A whey protein shake made with water”	Wording changed for cultural appropriateness
2.1	First and second answer choices: “1 - 3 g carbohydrate per kg (0.016 - 0.048 ounces per lb) body weight per day” and “5 - 8 g carbohydrate per kg (0.08 -0.13 ounce per lb) body weight per day”	Added “(e.g. 70-200 g carbohydrate for a 150 lb athlete)” and “(e.g. 340-540 g for a 150 lb athlete)”	Examples of calculations added for clarity (anticipated lack of familiarity with body weight in kg and nutrient content in ounces)
2.3	First answer choice: “boiled rice”	“cooked brown rice”	Wording changed for cultural appropriateness, and to reflect potential misconception that whole grains are lower in carbohydrate.
2.4-3	“For athletes, no more than 20g of fat should be eaten per day”	“Ranch dressing is high in unsaturated fat”	Item changed to assess procedural knowledge and evaluate understanding of different types of fat.
2.4-4	“When exercise intensity increases, the relative amount (%) of fat that is burnt to supply the body with fuel increases”	“Foods high in unsaturated fat may promote inflammation and impair muscle recovery”	Original item is repetitive of question # 22; item changed to assess declarative knowledge in correlation with question #20 and to evaluate knowledge of food/physical performance relationship.
2.4-5	“When exercising at low	“Fat is the primary	Wording simplified to

	intensities, fat provides almost all the substrate needed to cover energy costs"	source of energy during low-intensity exercise (e.g. steady-state cardio)"	reduce respondent fatigue
2.6-3	"A well-trained athlete needs more protein than a young athlete who is just beginning training"	"An athlete trying to maintain their weight needs more protein than an athlete trying to lose weight"	Item changed to reflect the limited age range of the population of interest; understanding protein needs for different weight management goals is more pertinent in the ROTC population.
2.9	"100 g (3 ounces) Chicken breast" "30 g (1 ounce) yellow cheese", "1 cup baked beans" "½ cup cooked quinoa"	"1 cup baked beans" "1 cup almond milk" "1 tablespoon peanut butter"	Chicken breast removed because it is already included in question #32; the given portions of cheese and quinoa are similar in protein content (4-6 grams); almond milk and peanut butter added because of culturally familiarity with foods and potential misconceptions surrounding their protein content.
2.10	Removed	N/A	Protein is covered comprehensively with the preceding questions
2.11	Removed	N/A	Protein is covered comprehensively with the preceding questions
3.1-1	"Calcium is the largest structural component of bone crystals"	"Potassium is important for fluid and electrolyte balance"	Item changed to evaluate declarative knowledge to correlate with question #42 regarding food sources of potassium (procedural knowledge)
3.1-2	"Vitamin C acts as an anti-oxidant in the body"	"Anti-oxidants, such as Vitamin C, are important	Item changed to evaluate understanding of the importance of antioxidants

		for muscle recovery and injury prevention"	for physical performance
3.2-2	"Wholegrain foods are the best sources of vitamin C"	"Sweet potatoes are higher in potassium than white or russet potatoes"	Item changed to include popular American food choices, and to reflect misconception that white potatoes are "unhealthy" or less nutritious than sweet potatoes [77]
N/A	N/A	Item added: "Tart cherries, walnuts, carrots, and bell peppers are all high in antioxidants"	Item added to assess procedural knowledge in correlation with question #38
3.2-4	"Fruit and vegetables are the best sources of calcium"	"Fruits and vegetables are the best sources of B vitamins"	Item changed to assess procedural knowledge in correlation with question #39 regarding the role of vitamin B1
3.2-4	"Milk, yogurt and cheese are the best sources of magnesium"	"Milk, yogurt and cheese are the best sources of iron"	Item changed to assess procedural knowledge in correlation with question #40 regarding the role of iron and to reflect noted gap in knowledge of iron sources; Item may also be used to assess understanding of the fact that calcium may inhibit iron absorption.
3.3-3	"The optimal calcium intake for athletes aged 15 to 24 years is 500 mg"	"Athletes may need to consume more Vitamin D during the winter months"	Item changed to better assess procedural knowledge
4.3	Question: "How much carbohydrate should fluid consumed for hydration purposes (during exercise)	Question: "What type of fluid should be consumed during	Question changed to better assess procedural knowledge

	contain?" Answers: " o None o At least 1 - 2 % carbohydrate o At least 4 - 8 % carbohydrate o Not Sure"	intense exercise lasting over an hour?" Answers: " o Water only o 100% Fruit juice o Sports drink (e.g. Gatorade or Powerade) o Low-calorie/ sugar-free sports drink (e.g. Powerade Zero or G2 Gatorade) or a watered-down sports drink o Not sure"	
4.4	Question: "How much sodium (salt) should fluid consumed for hydration purposes (during exercise) contain?" Answers: " o At least 11 - 25 mmol/L (~ 250 - 575 mg/L) o At least 4 - 8 mmol/L (~ 90 - 185 mg/L) o None o Not Sure"	Question: "Which of the following is true?" Answers: " o Sodium consumption during exercise may cause water retention and should be avoided. o Potassium tablets are recommended to prevent muscle cramping during exercise o A sports drink containing 500-700 mg of sodium is appropriate for	Question changed to better assess procedural knowledge

		maintaining electrolyte balance ○ Not sure”	
4.11	First answer choice: “0.3g/kg body weight (~ 15 - 25 g [0.53 - 0.88 ounces] for most athletes)” Second answer choice: “1.0 g/kg body weight (~ 50 - 100 g [(1.9 - 2.3 ounces)] for most athletes)” Third answer choice: “1.5g/kg body weight (~ 150 – 130 g [5.3 – 10.6 ounces] for most athletes)”	First answer Choice: “15-40 grams” Second answer choice: “50-100 grams” Third answer choice: “150-130 grams”	Answer choices simplified to reduce respondent fatigue
5.5	Answer choices: “caffeine, ferulic acid, bicarbonate, leucine, not sure”	Answer choices: “caffeine, branched-chain amino acids (BCAAs), creatine, tart cherry juice, not sure”	Answer choices changed to reflect widely used and recognized supplements; correct answer changed to BCAAs due to high reported use of BCAAs by ROTC cadets. [10]
5.6	Correct Answer: “Glycerol”	Correct Answer: “Dimethylamylamine (DMAA)”	Answer choice changed to reflect recent removal of glycerol from WADA banned list; changed to DMAA to evaluate knowledge of the potential danger of pre-workout supplements and the DMAA-related deaths discussed in the literature review.

6.1	Question: "How many grams/ fluid ounces of ethanol (pure alcohol) does a standard drink generally contain?" Answers: " o 1 - 2 g/ 0.03 - 0.06 fluid ounces o 8 - 14 g/ 0.3 - 0.6 fluid ounces o 30 - 50 g /1.2-2.0 fluid ounces o Not sure"	Question: "How many calories per gram does alcohol contain?" Answers: " o 0 o 4 o 7 o 9 o Not sure"	Question changed to encompass question 6.3 and better assess understanding of alcohol's energy content/potential contribution to weight gain.
6.2	First Answer Choice: "30 - 45 ml/1 - 1.5 fluid ounces of pure spirits"	First Answer Choice: "1.0-1.5 ounces of liquor"	Answer choice simplified to improve respondent understanding
6.3	Question removed "When consumed as part of the diet, pure alcohol (ethanol) contains calories/kilojoules and, therefore, can lead to weight gain."	N/A	Repetitive to include with question #6.1/76 (see above)
6.4	"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:"	"For individuals who choose to drink alcohol, no more than ___ standard drinks should be consumed per day, to reduce the risk of alcohol-related harm over a lifetime. "	Question re-worded to ease understanding
6.5-1	"If someone does not drink at all during the week, it is okay for them to have five or more	"Alcohol may increase testosterone levels"	Original statement is subjective in nature and does not assess knowledge of specific performance-related

	drinks on a Friday or Saturday night"		consequences of alcohol consumption
6.5-3	"Alcohol has been shown to increase urinary losses during postexercise recovery"	"Alcohol consumption can increase the risk of vitamin and mineral deficiencies"	Original question is unclear; changed to assess knowledge of long-term performance-related consequences of alcohol consumption.
Original Question #	Original Question/ Statement/ Answer Choice	Modified Question/ Statement/ Answer Choice	Rationale for change
1.3- 1 2.5- 2	"canola spread (polyunsaturated margarine)"	"canola-oil spread or margarine"	To increase recognition and reduce use of complex/scientific wording
1.3-3	"Exchange yogurts, muesli/granola bars and fruit snacks for protein bars and shakes"	"Exchange yogurt, granola bars, and fruit for protein bars and shakes"	"Muesli" was removed to reflect lack of cultural familiarity; "snacks" was removed to avoid confusion with fresh fruit and the popular American food product "Fruit Snacks".
1.3-4	"Choose lower glycemic index (GI) carbohydrates"	"Split up protein intake evenly throughout the day"	No questions evaluate participants' understanding of glycemic index; protein timing is considered an important factor in maintaining muscle mass while losing weight. [110]
1.5	First answer choice: "Plan their diet according to their age, gender, body size, sport and training program"	"Plan their diet according to their age, gender, body size and physical activity level"	Wording changed to be generalizable to non-sport specific athletes, such as ROTC cadets or military personnel.
1.5	Second answer choice: "Eat to appetite following their natural hunger and fullness signals"	"Eat the same amount of calories that they expend during training"	Listening to appetite and eating intuitively may be an appropriate weight management strategy for athletes and should not be

			denounced.
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2.4-5	“When exercising at low intensities, fat provides almost all the substrate needed to cover energy costs”	“Fat is the primary source of energy during low-intensity exercise (e.g. steady-state cardio)”	Wording simplified to reduce respondent fatigue
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			knowledge)
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3.3-3	"The optimal calcium intake for athletes aged 15 to 24 years is 500 mg"	"Athletes may need to consume more Vitamin D during the winter months"	Item changed to better assess procedural knowledge

4.3	Question: "How much carbohydrate should fluid consumed for hydration purposes (during exercise) contain?" Answers: " o None o At least 1 - 2 % carbohydrate o At least 4 - 8 % carbohydrate o Not Sure"	Question: "What type of fluid should be consumed during intense exercise lasting over an hour?" Answers: " o Water only o 100% Fruit juice o Sports drink (e.g. Gatorade or Powerade) o Low-calorie/ sugar-free sports drink (e.g. Powerade Zero or G2 Gatorade) or a watered-down sports drink o Not sure"	Question changed to better assess procedural knowledge
4.4	Question: "How much sodium (salt) should fluid consumed for hydration purposes (during exercise) contain?" Answers: " o At least 11 - 25 mmol/L (~ 250 - 575 mg/L) o At least 4 - 8 mmol/L (~ 90 - 185 mg/L) o None o Not Sure"	Question: "Which of the following is true?" Answers: " o Sodium consumption during exercise may cause water retention and should be avoided. o Potassium tablets are recommended to prevent muscle cramping during exercise	Question changed to better assess procedural knowledge

		○ A sports drink containing 500-700 mg of sodium is appropriate for maintaining electrolyte balance ○ Not sure”	
4.11	First answer choice: “0.3g/kg body weight (~ 15 - 25 g [0.53 - 0.88 ounces] for most athletes)” Second answer choice: “1.0 g/kg body weight (~ 50 - 100 g [(1.9 - 2.3 ounces)] for most athletes)” Third answer choice: “1.5g/kg body weight (~ 150 – 130 g [5.3 – 10.6 ounces] for most athletes)”	First answer Choice: “15-40 grams” Second answer choice: “50-100 grams” Third answer choice: “150-130 grams”	Answer choices simplified to reduce respondent fatigue
5.5	Answer choices: “caffeine, ferulic acid, bicarbonate, leucine, not sure”	Answer choices: “caffeine, branched-chain amino acids (BCAAs), creatine, tart cherry juice, not sure”	Answer choices changed to reflect widely used and recognized supplements; correct answer changed to BCAAs due to high reported use of BCAAs by ROTC cadets. [10]
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6.1	Question: "How many grams/ fluid ounces of ethanol (pure alcohol) does a standard drink generally contain?" Answers: " o 1 - 2 g/ 0.03 - 0.06 fluid ounces o 8 - 14 g/ 0.3 - 0.6 fluid ounces o 30 - 50 g /1.2-2.0 fluid ounces o Not sure"	Question: "How many calories per gram does alcohol contain?" Answers: " o 0 o 4 o 7 o 9 o Not sure"	Question changed to encompass question 6.3 and better assess understanding of alcohol's energy content/potential contribution to weight gain.
6.2	First Answer Choice: "30 - 45 ml/1 - 1.5 fluid ounces of pure spirits"	First Answer Choice: "1.0-1.5 ounces of liquor"	Answer choice simplified to improve respondent understanding
6.3	Question removed "When consumed as part of the diet, pure alcohol (ethanol) contains calories/kilojoules and, therefore, can lead to weight gain."	N/A	Repetitive to include with question #6.1/76 (see above)
6.4	"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:"	"For individuals who choose to drink alcohol, no more than ___ standard drinks should be consumed per day, to reduce the risk of alcohol-related harm over a lifetime."	Question re-worded to ease understanding

6.5-1	"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"	"Alcohol may increase testosterone levels"	Original statement is subjective in nature and does not assess knowledge of specific performance-related consequences of alcohol consumption
6.5-3	"Alcohol has been shown to increase urinary losses during postexercise recovery"	"Alcohol consumption can increase the risk of vitamin and mineral deficiencies"	Original question is unclear; changed to assess knowledge of long-term performance-related consequences of alcohol consumption.

Appendix C. 82-Item Modified Nutrition for Sport Knowledge Questionnaire: Validation Questionnaire Key and Response Frequencies

= *Questions with ≥ 50% incorrect responses*
= *Correct Answer*

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

#	Question	Agree	Disagree	Not sure	Total
1	In endurance sports, having the lowest weight possible benefits performance in the long term	5.88%	88.24%	5.88%	17
2	Increasing protein in the diet is the main dietary change needed when only muscle gain is desired	5.88%	88.24%	5.88%	17
3	Protein eaten in excess of bodily needs can lead to fat gain	76.47%	17.65%	5.88%	17

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

#	Question	Effective	Not Effective	Not sure	Total
1	Increase the intake of low-calorie foods such as vegetables.	93.75%	0.00%	6.25%	16
2	Use canola-oil spread or margarine instead of butter	18.75%	68.75%	12.50%	16
3	Snack on protein bars instead of yogurt, granola bars or fruit	12.50%	81.25%	6.25%	16
4	Spread protein intake evenly throughout the day	100.00%	0.00%	0.00%	16
5	Stop eating carbohydrate-containing foods (e.g., rice and pasta) after 4 PM	6.25%	87.50%	6.25%	16

When weight loss is desired, generally athletes should: Choose one answer.

#	When weight loss is desired, generally athletes should: Choose one answer.	Percentage
1	Decrease carbohydrate intake to less than 50 grams (1.7 ounces) per day	0.00%
2	Decrease fat intake to less than 20 grams (0.7 ounces) per day	0.00%
3	Decrease total calorie intake by decreasing carbohydrate, protein, and fat intake	87.50%
4	Not sure	12.50%

	Total	16

To ensure they meet their energy (calorie) requirements, all athletes should: Choose one answer.

#	To ensure they meet their energy (calorie) requirements, all athletes should: Choose one answer.	Percentage
1	Plan their diet according to their age, sex, body size and physical activity level	100.00%
2	Eat the same amount of calories that they expend during training	0.00%
3	Eat a minimum of 2000 calories per day	0.00%
4	Choose foods that are high-protein, low-carbohydrate meals	0.00%
5	Not Sure	0.00%
	Total	16

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

#	Which do you think is the best lunch option for an athlete trying to gain weight (muscle)? Assume they are training in the morning and have already had breakfast and a mid-morning snack. Choose one answer.	Percentage
1	A 'mass gainer' protein shake and 3-4 scrambled eggs	0.00%
2	Pasta with lean ground beef and marinara sauce, plus a dessert of fruit, yogurt and nuts	87.50%
3	A large piece of grilled chicken with a side salad (lettuce, cucumber, tomato)	6.25%
4	A large steak and fried eggs	0.00%
5	Not sure	6.25%
	Total	16

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. Choose one answer.

#	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. Choose one answer.	Percentage
1	A side salad with no dressing (lettuce, cucumber, tomato)	0.00%
2	A whey protein shake made with water	0.00%
3	A mixed meal that includes a small-moderate serving of meat and carbohydrate (e.g. small bowl of pasta with lean ground beef and marinara sauce) plus a large side salad	100.00%
4	Not sure	0.00%

	Total	16

Macronutrients

Which nutrient do you think has the most energy (calories) per 100 grams (3.5 ounces)? Choose one answer.

#	Which nutrient do you think has the most energy (calories) per 100 grams (3.5 ounces)? Choose one answer.	Percentage
1	Carbohydrate	0.00%
2	Protein	0.00%
3	Fat	100.00%
4	Not sure	0.00%
	Total	16

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? Choose one answer.

#	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? Choose one answer.	Percentage
1	1-3 g carbohydrate per kg (0.016-0.048 ounces per lb) body weight per day (e.g. 70-200 g carbohydrate for a 150 lb athlete)	0.00%
2	5-8 g carbohydrate per kg (0.08-0.013 ounces per lb) body weight per day (e.g. 340-540 g for a 150 lb athlete)	100.00%
3	15-25% of total daily calorie intake	0.00%
4	75-85% of total daily calorie intake	0.00%
5	Not sure	0.00%
	Total	16

Do you think these foods are high or low in carbohydrates?

#	Question	High	Low	Not Sure	Total
1	1 medium banana	100.00%	0.00%	0.00%	16
2	½ cup cooked quinoa	100.00%	0.00%	0.00%	16
3	1 tablespoon butter	0.00%	100.00%	0.00%	16
4	1 cup baked beans	93.75%	6.25%	0.00%	16

Which of the following foods do you think contains the most carbohydrate? Choose one answer.

#	Which of the following foods do you think contains the most carbohydrate? Choose one answer.	Percentage
1	1 cup of cooked brown rice	87.50%
2	2 slices of white sandwich bread	0.00%
3	1 medium (150 g/ 5 ounce) boiled potato	12.50%
4	1 medium (150 g/5 ounce) ripe banana	0.00%
5	Not sure	0.00%
	Total	16

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

#	Question	Agree	Disagree	Not sure	Total
1	Fat is required by the body to make cell membranes and molecules involved in immune function	100.00%	0.00%	0.00%	16
2	Ranch dressing is high in unsaturated fat	25.00%	62.50%	12.50%	16
3	Foods high in unsaturated fat may promote inflammation and impair muscle recovery	18.75%	75.00%	6.25%	16
4	Fat is the primary source of energy during low-intensity exercise (e.g., steady-state cardio)	93.75%	6.25%	0.00%	16

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

#	Question	High	Low	Not sure	Total
1	1 Tablespoon canola-oil spread/ margarine	100.00%	0.00%	0.00%	16
2	¼ cup mixed nuts	100.00%	0.00%	0.00%	16
3	1 Tablespoon honey	0.00%	100.00%	0.00%	16

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

#	Question	Agree	Disagree	Not Sure	Total
1	Protein is the main source of energy used by muscles during exercise	0.00%	100.00%	0.00%	16
2	Vegetarian athletes can meet their protein requirements without the use of protein supplements	93.75%	6.25%	0.00%	16
3	An athlete trying to maintain their weight needs more protein than an athlete trying to lose weight	0.00%	93.75%	6.25%	16
4	Protein can contribute to fat gain when consumed in excess	81.25%	18.75%	0.00%	16
5	Excessive protein intake can lead to dehydration	62.50%	18.75%	18.75%	16

Which of the following foods do you think contains the most protein? Choose one answer.

#	Which of the following foods do you think contains the most protein? Choose one answer.	Percentage
1	2 eggs	6.25%
2	100 g (3 ounces) raw skinless chicken breast	93.75%
3	30 g (1 ounce) almonds	0.00%
4	Not sure	0.00%
	Total	16

The protein needs of a 100 kg (220 lb) well-trained resistance athlete are closest to: Choose one answer.

#	The protein needs of a 100 kg (220 lb) well-trained resistance athlete are closest to: Choose one answer.	Percentage
1	75 g (2.7 ounces) per day	0.00%
2	130 g (4.6 ounces) per day	75.00%
3	250 g (8.8 ounces) per day	25.00%
4	They should eat as much protein as possible	0.00%
5	Not sure	0.00%
	Total	16

Do you think these foods are high or low in protein?

#	Question	High	Low	Not Sure	Total
1	1 cup baked beans	81.25%	18.75%	0.00%	16
2	1 cup almond milk	6.25%	93.75%	0.00%	16
3	1 tablespoon peanut butter	56.25%	43.75%	0.00%	16

Micronutrients

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

#	Question	Agree	Disagree	Not sure	Total
1	Potassium is important for fluid and electrolyte balance.	100.00%	0.00%	0.00%	16
2	Antioxidants, such as Vitamin C, are important in muscle recovery and injury prevention.	87.50%	12.50%	0.00%	16
3	Thiamine (Vitamin B1) is required for the efficient delivery of oxygen to muscles	37.50%	50.00%	12.50%	16
4	The main role of iron is the conversion of food into usable energy	6.25%	87.50%	6.25%	16
5	Calcium and Vitamin D are important for injury prevention.	100.00%	0.00%	0.00%	16

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

#	Question	Agree	Disagree	Not sure	Total
1	Meat, chicken and fish are the best sources of zinc	75.00%	25.00%	0.00%	16
2	Sweet potatoes are higher in potassium than white potatoes	43.75%	43.75%	12.50%	16
3	Tart cherries, walnuts, carrots, and bell peppers are all high in antioxidants.	100.00%	0.00%	0.00%	16
4	Fruits and vegetables are the best sources of B vitamins	12.50%	87.50%	0.00%	16
5	Milk, yogurt and cheese are the best sources of iron	0.00%	100.00%	0.00%	16
6	Salmon is a good source of Vitamin D	56.25%	37.50%	6.25%	16

The following statements are about athletes' vitamin and mineral requirements. Please select agree, disagree or not sure

#	Question	Agree	Disagree	Not sure	Total
1	Athletes have increase magnesium needs due to losses in sweat	68.75%	25.00%	6.25%	16

2	Women who are menstruating have higher irons needs than men	87.50%	6.25%	6.25%	16
3	Athletes may need to consume more vitamin D during the winter months	100.00%	0.00%	0.00%	16
4	A physically fit person eating a nutritionally adequate diet can improve their performance by eating more vitamins and minerals.	6.25%	87.50%	6.25%	16
5	Vitamins provide the body with energy (calories)	0.00%	100.00%	0.00%	16

Hydration

Athletes should drink water during activity in order to: Choose one answer.

#	Athletes should drink water during activity in order to: Choose one answer.	Percentage
1	Maintain plasma (blood) volume	18.75%
2	Prevent dry mouth	0.00%
3	Maintain sweat volume	0.00%
4	All of the above	81.25%
5	Not sure	0.00%
	Total	16

Regarding fluid intake during physical activity, current recommendations encourage athletes to: Choose one answer.

#	Regarding fluid intake during physical activity, current recommendations encourage athletes to: Choose one answer.	Percentage
1	Drink 50-100 mL (1.7-3.3 fluid ounces) every 15-20 minutes	50.00%
2	Suck on ice cubes rather than drinking during training	0.00%
3	Drink sports drinks (e.g. Gatorade) instead of water when exercising	6.25%
4	Hydrate according to changes in body weight that occur during training sessions	43.75%
	Total	16

What type of fluid should be consumed during intense exercise lasting over an hour? Choose one answer.

#	What type of fluid should be consumed during intense exercise lasting over an hour? Choose one answer.	Percentage
1	Water only	0.00%
2	100% Fruit juice	0.00%
3	Sports drink (e.g. Gatorade or Powerade)	100.00%

4	Low-calorie/ sugar-free sports drink (e.g. Powerade Zero or G2 Gatorade) or a watered-down sports drink	0.00%
5	Not sure	0.00%
	Total	16

Which of the following is true? Choose one answer.

#	Which of the following is true? Choose one answer.	Percentage
1	Sodium consumption during exercise may cause water retention and should be avoided	0.00%
2	Potassium tablets are recommended to prevent muscle cramping during exercise	0.00%
3	A sports drink containing 150-180 mg of sodium per 8 fluid ounces is appropriate for maintaining electrolyte balance	100.00%
4	Not sure	0.00%
	Total	16

Nutrient Timing

Before training, athletes should consume foods that are high in: Choose one answer.

#	Before training, athletes should consume foods that are high in: Choose one answer.	Percentage
1	Fluids, fat, and carbohydrate	0.00%
2	Fluids, fiber, and carbohydrate	0.00%
3	Fluids and carbohydrate	100.00%
4	Not sure	0.00%
	Total	16

The following statements are about carbohydrate consumption during exercise

#	Question	Agree	Disagree	Not sure	Total
1	Consuming carbohydrate during exercise can reduced ability to develop strength and muscle gains	0.00%	93.75%	6.25%	16
2	In events lasting 60-90 minutes, 30-60 g (1.0-2.0 ounces) of carbohydrates should be consumed per hour	87.50%	12.50%	0.00%	16
3	Consuming carbohydrate during exercise will assist in maintaining blood glucose levels	93.75%	6.25%	0.00%	16

During exercise, athletes should aim to consume foods that are high in: Choose one answer.

#	During exercise, athletes should aim to consume foods that are high in: Choose one answer.	Percentage
1	Fluids, fiber and fat	0.00%
2	Fluids and protein	0.00%
3	Fluids and carbohydrate	100.00%
4	Not sure	0.00%
	Total	16

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

#	Which of the following best meets the recommendations for a snack consumed during high-intensity exercise lasting around 90 minutes? Choose one answer.	Percentage
1	A protein shake	0.00%
2	A ripe banana	100.00%
3	2 boiled eggs	0.00%
4	A handful of nuts	0.00%
5	Not sure	0.00%
	Total	16

How much protein do you think experts recommend athletes consume after completing a resistance exercise session? Choose one answer.

#	How much protein do you think experts recommend athletes consume after completing a resistance exercise session? Choose one answer.	Percentage
1	15-40 grams	100.00%
2	50-100 grams	0.00%
3	150-130 grams	0.00%
4	Not sure	0.00%
	Total	16

Supplementation

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

#	Question	Agree	Disagree	Not sure	Total
1	Vitamin C should be routinely supplemented by athletes	6.67%	86.67%	6.67%	15
2	B vitamins should be taken when feeling low	20.00%	73.33%	6.67%	15

	in energy				
3	Multivitamins are generally necessary for all athletes because of their high energy needs	6.67%	86.67%	6.67%	15
4	Iron tablets should be taken when a player feels extremely tired and is pale	26.67%	60.00%	13.33%	15

The purity and safety of all supplements are tested before sale

#	The purity and safety of all supplements are tested before sale	Percentage
1	Agree	0.00%
2	Disagree	100.00%
3	Not sure	0.00%
	Total	15

Supplement labels may contain false or misleading information

#	Supplement labels may contain false or misleading information	Percentage
1	Agree	100.00%
2	Disagree	0.00%
3	Not sure	0.00%
	Total	15

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

#	Question	Agree	Disagree	Not sure	Total
1	Creatine reduces perceived effort of exercise by acting on the central nervous system	6.67%	80.00%	13.33%	15
2	Consuming caffeine before exercise may cause stomach upset.	73.33%	20.00%	6.67%	15
3	Beetroot juice (nitrates) decrease muscle breakdown and reduce muscle soreness	20.00%	80.00%	0.00%	15
4	Beta-alanine produces carnosine, a protein that can buffer (“soak up”) acid by-products produced during high-intensity activity	80.00%	6.67%	13.33%	15

In relation to improving sporting performance, which of the following supplements do you think has NOT been supported by a strong body of scientific evidence? Choose one answer.

#	In relation to improving sporting performance, which of the following supplements do you think has NOT been supported by a strong body of scientific evidence? Choose one answer.	Percentage
1	Caffeine	6.67%
2	Branched-chain Amino Acids (BCAAs)	86.67%
3	Creatine	0.00%
4	Tart cherry juice	6.67%
5	Not sure	0.00%
	Total	15

Which of the following supplements do you think is banned by the World Anti-Doping Agency (WADA)? Choose one answer.

#	Which of the following supplements do you think is banned by the World Anti-Doping Agency (WADA)? Choose one answer.	Percentage
1	Caffeine	6.67%
2	Bicarbonate	0.00%
3	Carnitine	0.00%
4	Dimethylamylamine (DMAA)	93.33%
5	Not sure	0.00%
	Total	15

Alcohol

How many calories per gram does alcohol contain? (carbohydrates= 4 calories per gram, protein= 4 calories per gram and fat= 9 calories per gram) Choose one answer.

#	How many calories per gram does alcohol contain? (carbohydrates= 4 calories per gram, protein= 4 calories per gram and fat= 9 calories per gram) Choose one answer.	Percentage
1	0	0.00%
2	4	0.00%
3	7	100.00%
4	9	0.00%
	Total	15

Which of the following do you think is an example of a “standard drink” size? Choose one answer.

#	Which of the following do you think is an example of a “standard drink” size? Choose one answer.	Percentage
1	1.0-1.5 ounces of liquor	93.33%
2	One quarter of a bottle (6 fluid ounces) of red wine	0.00%
3	A pint (16 fluid ounces) of regular beer (i.e., not light)	6.67%
4	Not sure	0.00%
	Total	15

For individuals who choose to drink alcohol, no more than ___ standard drinks should be consumed per day, to reduce the risk of alcohol-related harm over a lifetime. Choose one answer.

#	For individuals who choose to drink alcohol, no more than ___ standard drinks should be consumed per day, to reduce the risk of alcohol-related harm over a lifetime. Choose one answer.	Percentage
1	Two	100.00%
2	Three	0.00%
3	Four	0.00%
4	Not sure	0.00%
	Total	15

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

#	Question	Agree	Disagree	Not sure	Total
1	Alcohol may increase testosterone levels	0.00%	80.00%	20.00%	15
2	Drinking large amounts of alcohol can reduce recovery from injury	86.67%	6.67%	6.67%	15
3	Alcohol consumption can increase the risk of vitamin and mineral deficiencies	100.00%	0.00%	0.00%	15

“Binge drinking” is generally defined as: Choose one answer.

#	“Binge drinking” is generally defined as: Choose one answer.	Percentage
1	Having two or more standard alcoholic drinks on the same occasion	6.67%
2	Having four to five or more standard alcoholic drinks on the same occasion	80.00%
3	Having seven to eight or more standard alcoholic drinks on the same occasion	0.00%
4	Not sure	13.33%

Appendix D. Validation Questionnaire Qualitative Feedback

Weight Management

"I do believe CHO restriction is effective for weight loss - but not necessarily down to 50g (under 200g, for example can be effective)."

"Unsure why this is seeming to ask us for a one size fits all response. Most things on here I would respond with, "it depends". It depends on what the athlete is trying to accomplish alongside the weight management."

"While a strength of these questions is that they are very practically-focused, they are difficult to answer because so many of them depend on the athlete or the situation. Many answers could be correct. "Should" seems to strong. It may be advisable to ask more fact-based questions than situational."

Macronutrients

"The question 'Foods high in unsaturated fat may promote inflammation and impair muscle recovery' is misleading. I personally selected 'Agreed' becuase while saturated fats promote inflammation (and Omega 3's can reduce it) so do Omega 6's (which are unsaturated) when eaten in high doses...I feel like it's impossible to answer this question correctly. For the question 'Ranch dressing is high in unsaturated fat'- can you define 'high' according to the FDA."

"Qualifications on answers: Protein needs of a 100 kg athlete, do you mean 250 g protein or 8.8 ounce equivalent of protein, depends on how I read that as to the answer I would choose, 250 g protein is too high, 130 g protein not enough, but if in ounces, 8.8 ounces is not as much as I would want them to have. When you use high or low, it is a relative term and likely means something different to each of us. Peanut butter is a protein source but I do not feel it is high in protein unless you are comparing it to honey or something... Maybe you should define high and low or how you want the reader to read those.
Error in 5-8 g Carb answer for 2nd question? Number of oz? 2nd time question about excess protein leading to weight gain appeared."

"In the question regarding which foods are "high or low in carbohydrate... banana/quinoa/butter/beans" I think more appropriate wording would be "higher or lower" or given from a standard such as "over 30 grams of carbohydrate" or even "compared to other foods listed" to maintain accuracy. "High or low" seems subjective. The same goes for the similar questions on fat and protein."

"The (ounces) is odd. Perhaps an IRB thing. Mixing g/kg and % of kcals mixes two different questions (way to express carb needs and knowledge of levels). Suggest choosing one (g/kg) for all choices.

"Some processed ranch dressings are high in unsat fat. Need to quantify the protein and weight loss question. needs are higher not just if someone is "trying" to lose

weight, but if they are in negative energy balance. Define "high" and "low" protein.""

Micronutrients

"Iron is tricky. RDA is higher for menstruating women, but needs for athletes depends highly on type and duration of training. An endurance trained male may need more as would an iron deficient male. typo in the Mg question"

Hydration

"The questions/answers with exact numerical values may be a bit too specific for general population individuals."
"Many of the answers that must be correct by process of elimination are not the answers I would put on a test."
"2nd question: 3rd and 4th answer choice are accurate 3rd question: sports drink recommended IF the goal is enhancing performance."

Nutrient Timing

"Noticed a typo - "consuming CHO during exercise can reduced""

"The carb consumption during exercise questions seem odd. For #2 what type of activity? Is this 60-90 of full high intensity race or is this a soccer match, one scenario may require carbs whereas the other (soccer) may not. As for the blood glucose question it is just an odd question. The remainder of questions on this page I thought were very good for determining possible lack of nutrition of knowledge."

"There is a typo on this question "The following statements are about carbohydrate consumption during exercise... consuming carbohydrate during exercise can" reduce, not reduced."

"typo in first question on table"

Supplementation

"The first supplementation question could have another category listed as "maybe.. depending on additional factors""

"BCAAs and tart cherry - niether have STRONG evidence base WADA not relevant to your population. Good to ask about DMAA tho."

Alcohol

"CDC guidelines for alcohol are 1 standard drink a day for women and 2 for men. You need to adjust your question on this."
"some questions are more focused on general nutrition, not sports performance."

Appendix E. Demographic Questions

What is your sex?
- Male
- Female

What is your race/ ethnicity? Check all that apply.
- White
- Black or African American
- American Indian or Alaska Native
- Asian
- Native Hawaiian or Pacific Islander
- Hispanic
- Other, list _____

What is your current grade level?
- Freshman
- Sophomore
- Junior
- Senior
- 5th year
- Other, list: _____

What is your major?

Have you ever met with a student nutrition counselor at Virginia Tech?
- Yes
- No

What are your primary sources of nutrition information? (check all that apply)
- Internet
- Health/fitness bloggers or social media personalities
- Government resources (i.e. USDA MyPlate.gov, Medline Plus, Dietary Guidelines for Americans)
- Primary care doctor
- Registered Dietitian or student nutrition counselor
- Family and friends
- Personal Trainer
- Academic journals
- Information through cadet chain of command
- Other _____

How would you rate your level of nutrition knowledge?
- No knowledge
- Little knowledge
- Some knowledge

- Knowledgeable
- Very knowledgeable

Do you have any dietary restrictions? Check all that apply.

- Lactose-intolerant
- Vegetarian
- Vegan
- Celiac Disease
- Food allergies; please specify:
- Other; please specify:

  _____

How would you rate your own diet quality?

- Very poor
- Poor
- Average
- Good
- Excellent

How strongly would you agree/disagree with the statement "I consider myself an athlete"?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Appendix F. 86-item Modified Nutrition for Sport Knowledge Questionnaire (M-NSKQ): Key and Response Frequencies

= correct response

Weight Management

Q20 - The following are statements about weight management. Please select agree, disagree, or not sure:

#	Question	Agree		Disagree		Not sure		Total
1	In endurance sports, having the lowest weight possible benefits performance in the long term	39.62%	42	49.06%	52	11.32%	12	106
2	Increasing protein in the diet is the main dietary change needed when only muscle gain is desired	39.62%	42	52.83%	56	7.55%	8	106
3	Protein eaten in excess of bodily needs can lead to fat gain	68.87%	73	15.09%	16	16.04%	17	106

Q21 - The following are some strategies one might try in order to lose weight (or reduce body fat). Please indicate if you think these are effective, not effective or you are not sure.

#	Question	Effective		Not Effective		Not sure		Total
1	Increase the intake of low-calorie foods such as vegetables.	90.65%	97	4.67%	5	4.67%	5	107
2	Use canola-oil spread or margarine instead of butter	42.99%	46	31.78%	34	25.23%	27	107
3	Snack on protein bars instead of yogurt, granola bars or fruit	11.43%	12	80.00%	84	8.57%	9	105
4	Spread protein intake evenly throughout the day	75.47%	80	9.43%	10	15.09%	16	106
5	Stop eating carbohydrate-containing foods (e.g., rice and pasta) after 4 PM	45.28%	48	33.02%	35	21.70%	23	106

Q22 - When weight loss is desired, generally athletes should: Choose one answer.

#	Answer	%	Count
1	Decrease carbohydrate intake to less than 50 grams (1.7 ounces) per day	19.81%	21
2	Decrease fat intake to less than 20 grams (0.7 ounces) per day	22.64%	24

3	Decrease total calorie intake by decreasing carbohydrate, protein, and fat intake	46.23%	49
4	Not sure	11.32%	12
	Total	100%	106

Q23 - To ensure they meet their energy (calorie) requirements, all athletes should: Choose one answer.

#	Answer	%	Count
1	Plan their diet according to their age, sex, body size and physical activity level	87.74%	93
2	Eat the same amount of calories that they expend during training	3.77%	4
3	Eat a minimum of 2000 calories per day	1.89%	2
4	Choose high-protein, low-carbohydrate meals	1.89%	2
5	Not Sure	4.72%	5
	Total	100%	106

Q24 - Which do you think is the best lunch option for an athlete trying to gain weight (muscle)? Assume they are training in the morning and have already had breakfast and a mid-morning snack. Choose one answer.

#	Answer	%	Count
1	A ‘mass gainer’ protein shake and 3-4 scrambled eggs	6.60%	7
2	Pasta with lean ground beef and marinara sauce, plus a dessert of fruit, yogurt and nuts	35.85%	38
3	A large piece of grilled chicken with a side salad (lettuce, cucumber, tomato)	46.23%	49
4	A large steak and fried eggs	4.72%	5
5	Not sure	6.60%	7
	Total	100%	106

Q25 - 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. Choose one answer.

#	Answer	%	Count
1	A side salad with no dressing (lettuce, cucumber, tomato)	21.50%	23
2	A whey protein shake made with water	1.87%	2

3	A mixed meal that includes a small-moderate serving of meat and carbohydrate (e.g. small bowl of pasta with lean ground beef and marinara sauce) plus a large side salad	71.96%	77
4	Not sure	4.67%	5
	Total	100%	107

Macronutrients

Q26 - Which nutrient do you think has the most energy (calories) per 100 grams (3.5 ounces)? Choose one answer.

#	Answer	%	Count
1	Carbohydrate	52.83%	56
2	Protein	14.15%	15
3	Fat	26.42%	28
4	Not sure	6.60%	7
	Total	100%	106

Q27 - 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? Choose one answer.

#	Answer	%	Count
1	1-3 g carbohydrate per kg body weight per day (e.g. 70-200 g carbohydrate for a 150 lb athlete)	15.24%	16
2	5-8 g carbohydrate per kg body weight per day (e.g. 340-540 g for a 150 lb athlete)	30.48%	32
3	15-25% of total daily calorie intake	31.43%	33
4	75-85% of total daily calorie intake	2.86%	3
5	Not sure	20.00%	21
	Total	100%	105

Q28 - Do you think these foods are significant sources of carbohydrates (at least 15 grams)?

#	Question	Yes		No		Not Sure		Total
1	1 medium banana	47.17%	50	40.57%	43	12.26%	13	106
2	½ cup cooked quinoa	76.42%	81	9.43%	10	14.15%	15	106

3	1 tablespoon butter	24.76%	26	66.67%	70	8.57%	9	105
4	1 cup kidney beans	55.24%	58	33.33%	35	11.43%	12	105

Q29 - Which of the following foods do you think contains the most carbohydrate? Choose one answer.

#	Answer	%	Count
1	1 cup of cooked brown rice	40.00%	42
2	2 slices of white sandwich bread	19.05%	20
3	1 medium (150 g) boiled potato	34.29%	36
4	1 medium (150 g) ripe banana	3.81%	4
5	Not sure	2.86%	3
	Total	100%	105

Q30 - The following statements are about fat. Please select agree, disagree or not sure.

#	Question	Agree		Disagree		Not sure		Total
1	Fat is required by the body to make cell membranes and molecules involved in immune function	81.90%	86	4.76%	5	13.33%	14	105
2	Most vinaigrette (oil-based) salad dressings are high in saturated fat	60.95%	64	20.00%	21	19.05%	20	105
3	Foods high in omega-3 fatty acids may promote inflammation and impair muscle recovery	20.95%	22	48.57%	51	30.48%	32	105
4	Fat is the primary source of energy during low-intensity exercise (e.g., steady-state cardio)	40.00%	42	34.29%	36	25.71%	27	105

Q31 - Do you think these foods are significant sources of fat (at least 7 grams or approximately 10% of the recommended daily value)?

#	Question	Yes		No		Not sure		Total
1	1/2 avocado	76.19%	80	18.10%	19	5.71%	6	105
2	¼ cup mixed nuts	69.23%	72	25.96%	27	4.81%	5	104

3	2 tablespoons maple syrup	37.50%	39	55.77%	58	6.73%	7	104
4	1 buttermilk biscuit	45.19%	47	45.19%	47	9.62%	10	104

Q32 - Which of the following foods do you think contains the most fat? Choose one answer.

#	Answer	%	Count
1	1 slice of regular cheddar cheese	6.67%	7
2	85 g (3 ounces) raw salmon	6.67%	7
3	2 slices of standard bacon	39.05%	41
4	2 tablespoons of peanut butter	43.81%	46
5	Not sure	3.81%	4
	Total	100%	105

Q33 - The following statements are about protein. Please select agree, disagree or not sure.

#	Question	Agree		Disagree		Not Sure		Total
1	Protein is the main source of energy used by muscles during exercise	35.85%	38	56.60%	60	7.55%	8	106
2	Vegetarian athletes can meet their protein requirements without the use of protein supplements	69.23%	72	20.19%	21	10.58%	11	104
3	An athlete trying to maintain their weight needs more protein than an athlete trying to lose weight	55.66%	59	36.79%	39	7.55%	8	106
4	Dairy products are good sources of whey and casein	57.55%	61	16.98%	18	25.47%	27	106
5	Excessive protein intake can lead to dehydration	68.87%	73	3.77%	4	27.36%	29	106

Q34 - Which of the following foods do you think contains the most protein? Choose one answer.

#	Answer	%	Count
1	2 eggs	36.54%	38
2	100 g (3 ounces) raw skinless chicken breast	49.04%	51

3	30 g (1 ounce) almonds	9.62%	10
4	1 cup whole milk	2.88%	3
5	Not sure	1.92%	2
	Total	100%	104

Q35 - The protein needs of a 100 kg (220 lb) well-trained strength athlete are closest to: Choose one answer.

#	Answer	%	Count
1	75 grams per day	18.87%	20
2	150 grams per day	50.00%	53
3	300 grams per day	17.92%	19
4	They should eat as much protein as possible	0.94%	1
5	Not sure	12.26%	13
	Total	100%	106

Q36 - Do you think these foods are significant sources of protein (at least 7 grams or a 1 ounce-equivalent)?

#	Question	High		Low		Not Sure		Total
1	1 cup kidney beans	85.85%	91	6.60%	7	7.55%	8	106
2	1 cup almond milk	58.10%	61	30.48%	32	11.43%	12	105
3	1/2 cup cottage cheese	50.00%	53	35.85%	38	14.15%	15	106
4	1 cup green peas	13.21%	14	72.64%	77	14.15%	15	106

Micronutrients

Q37 - The following are statements about the role of different micronutrients. Please select agree, disagree or not sure.

#	Question	Agree		Disagree		Not sure		Total
1	Potassium is important for fluid and electrolyte balance.	82.86%	87	1.90%	2	15.24%	16	105
2	Antioxidants, such as Vitamin C, are important in muscle recovery and injury prevention.	63.81%	67	18.10%	19	18.10%	19	105
3	Thiamine (Vitamin B1) is required for energy production during aerobic exercise	57.14%	60	7.62%	8	35.24%	37	105

4	The main role of iron is the conversion of food into usable energy	33.33%	35	26.67%	28	40.00%	42	105
5	Calcium and Vitamin D are important for injury prevention.	81.90%	86	6.67%	7	11.43%	12	105

Q38 - The following statements are about the food sources of different micronutrients. Please select agree, disagree or not sure.

#	Question	Agree		Disagree		Not sure		Total
1	Meat, chicken and fish are the best sources of zinc	56.60%	60	7.55%	8	35.85%	38	106
2	Baked potatoes are high in potassium	38.10%	40	29.52%	31	32.38%	34	105
3	Tart cherries, walnuts, carrots, and bell peppers are all high in antioxidants.	71.70%	76	8.49%	9	19.81%	21	106
4	Fruits and vegetables are the best sources of B vitamins	50.94%	54	12.26%	13	36.79%	39	106
5	Milk, yogurt and cheese are the best sources of iron	16.04%	17	50.94%	54	33.02%	35	106
6	Salmon is a good source of Vitamin D	38.10%	40	28.57%	30	33.33%	35	105

Q39 - The following statements are about athletes' vitamin and mineral requirements. Please select agree, disagree or not sure

#	Question	Agree		Disagree		Not sure		Total
1	Athletes with a higher sweat rate may have increased magnesium needs	60.38%	64	4.72%	5	34.91%	37	106
2	Female athletes who are menstruating have higher iron needs than healthy male athletes	67.92%	72	3.77%	4	28.30%	30	106
3	Athletes may need to consume more vitamin D during the winter months	64.15%	68	10.38%	11	25.47%	27	106
4	A physically fit person eating a nutritionally adequate diet can improve their performance by eating more vitamins and minerals.	59.43%	63	18.87%	20	21.70%	23	106
5	Vitamins provide the body with energy (calories)	16.04%	17	59.43%	63	24.53%	26	106

Hydration

Q40 - Athletes should drink water during activity in order to: Choose one answer.

#	Answer	%	Count
1	Maintain plasma (blood) volume	0.94%	1
2	Regulate body temperature	8.49%	9
3	Avoid abnormal increases in heart rate	0.00%	0
4	All of the above	84.91%	90
5	Not sure	5.66%	6
	Total	100%	106

Q41 - Regarding fluid intake during physical activity, current recommendations encourage athletes to: Choose one answer.

#	Answer	%	Count
1	Drink 50-100 mL (1.7-3.3 fluid ounces) every 15-20 minutes	42.45%	45
2	Suck on ice cubes rather than drinking during training	0.94%	1
3	Avoid sports drinks to limit added sugar consumption	25.47%	27
4	Hydrate according to changes in body weight that occur during training sessions (individual sweat rate)	31.13%	33
	Total	100%	106

Q42 - What type of fluid should be consumed during intense exercise lasting over an hour? Choose one answer.

#	Answer	%	Count
1	Water only	19.81%	21
2	100% Fruit juice	1.89%	2
3	Sports drink (e.g., Gatorade or Powerade)	23.58%	25
4	Low-calorie/ sugar-free sports drink (e.g., Powerade Zero or G2 Gatorade) or a watered-down sports drink	50.00%	53
5	Not sure	4.72%	5
	Total	100%	106

Q43 - Which of the following is true? Choose one answer.

#	Answer	%	Count
1	Sodium consumption during exercise may cause water retention and should be avoided	16.98%	18

2	Potassium tablets are recommended to prevent muscle cramping during exercise	18.87%	20
3	A sports drink containing 150-180 mg of sodium per 8 fluid ounces is appropriate for maintaining electrolyte balance	37.74%	40
4	Not sure	26.42%	28
	Total	100%	106

Nutrient Timing

Q44 - Before training, athletes should consume foods that are high in: Choose one answer.

#	Answer	%	Count
1	Fluids, fat, and carbohydrate	21.90%	23
2	Fluids, fiber, and carbohydrate	22.86%	24
3	Fluids and carbohydrate	49.52%	52
4	Not sure	5.71%	6
	Total	100%	105

Q45 - The following statements are about carbohydrate consumption during exercise

#	Question	Agree		Disagree		Not sure		Total
1	Consuming carbohydrate during exercise can reduce ability to develop strength and muscle gains	15.09%	16	49.06%	52	35.85%	38	106
2	For high-intensity exercise lasting 60-90 minutes, 30-60 grams of carbohydrates should be consumed per hour	43.40%	46	15.09%	16	41.51%	44	106
3	Consuming carbohydrate during exercise will assist in maintaining blood glucose levels	52.83%	56	12.26%	13	34.91%	37	106

Q46 - During exercise, athletes should aim to consume foods that are high in: Choose one answer.

#	Answer	%	Count
1	Fluids, fiber and fat	8.49%	9
2	Fluids and protein	33.96%	36
3	Fluids and carbohydrate	45.28%	48

4	Not sure	12.26%	13
	Total	100%	106

Q47 - Which of the following best meets the recommendations for a snack consumed during high-intensity exercise lasting around 90 minutes? Choose one answer.

#	Answer	%	Count
1	A protein shake	8.49%	9
2	A ripe banana	49.06%	52
3	2 boiled eggs	7.55%	8
4	A handful of nuts	30.19%	32
5	Not sure	4.72%	5
	Total	100%	106

Q48 - How much protein do you think experts recommend athletes consume after completing a resistance training session? Choose one answer.

#	Answer	%	Count
1	15-40 grams	44.34%	47
2	50-100 grams	33.96%	36
3	150-130 grams	12.26%	13
4	Not sure	9.43%	10
	Total	100%	106

Q49 - The following are statements about athletes' needs for particular micronutrient supplements. Please select agree, disagree or not sure.

#	Question	Agree		Disagree		Not sure		Total
1	Vitamin C should be routinely supplemented by athletes	51.89%	55	22.64%	24	25.47%	27	106
2	B vitamins should be taken when feeling low in energy	43.40%	46	16.98%	18	39.62%	42	106
3	Multivitamins are generally necessary for all athletes because of their high energy needs	47.17%	50	29.25%	31	23.58%	25	106
4	Iron tablets should be taken any time an athlete is pale and feels extremely tired	34.91%	37	24.53%	26	40.57%	43	106

Supplementation

Q50 - The purity and safety of all supplements are tested before sale

#	Answer	%	Count
1	Agree	13.21%	14
2	Disagree	71.70%	76
3	Not sure	15.09%	16
	Total	100%	106

Q51 - The purity and safety of all supplements sold on U.S. military bases are tested before sale

#	Answer	%	Count
1	Agree	32.08%	34
2	Disagree	47.17%	50
3	Not sure	20.75%	22
	Total	100%	106

Q52 - Supplement labels may contain false or misleading information

#	Answer	%	Count
1	Agree	83.02%	88
2	Disagree	9.43%	10
3	Not sure	7.55%	8
	Total	100%	106

Q53 - The following statements are about the reported benefits of performance-enhancing supplements. Please select agree, disagree or not sure.

#	Question	Agree		Disagree		Not sure		Total
1	Creatine reduces perceived effort of exercise by acting on the central nervous system	25.47%	27	27.36%	29	47.17%	50	106
2	Consuming caffeine before exercise may cause stomach upset.	70.75%	75	12.26%	13	16.98%	18	106
3	Beetroot juice (nitrates) decrease muscle breakdown and reduce muscle soreness	41.90%	44	6.67%	7	51.43%	54	105

4	Beta-alanine produces carnosine, a protein that can buffer (“soak up”) acid by-products produced during high-intensity activity	27.36%	29	5.66%	6	66.98%	71	106

Q54 - In relation to improving sporting performance, which of the following supplements do you think has NOT been supported by a strong body of scientific evidence? Choose one answer.

#	Answer	%	Count
1	Caffeine	29.25%	31
2	Branched-chain Amino Acids (BCAAs)	12.26%	13
3	Creatine	31.13%	33
4	Tart cherry juice	12.26%	13
5	Not sure	15.09%	16
	Total	100%	106

Q55 - Which of the following supplements do you think is banned by the World Anti-Doping Agency (WADA)? Choose one answer.

#	Answer	%	Count
1	Caffeine	3.77%	4
2	Bicarbonate	1.89%	2
3	Carnitine	14.15%	15
4	Dimethylamylamine (DMAA)	51.89%	55
5	Not sure	28.30%	30
	Total	100%	106

Alcohol

Q56 - How many calories per gram does alcohol contain? (carbohydrates= 4 calories per gram, protein= 4 calories per gram and fat= 9 calories per gram) Choose one answer.

#	Answer	%	Count
1	0	7.55%	8
2	4	33.02%	35
3	7	40.57%	43

4	9	18.87%	20
	Total	100%	106

Q57 - Which of the following do you think is an example of a "standard drink" size? Choose one answer.

#	Answer	%	Count
1	1.0-1.5 ounces of liquor	64.15%	68
2	One quarter of a bottle (6 fluid ounces) of red wine	16.98%	18
3	A pint (16 fluid ounces) of regular beer (i.e., not light)	14.15%	15
4	Not sure	4.72%	5
	Total	100%	106

Q58 - For individuals who choose to drink alcohol, no more than ___ standard drinks should be consumed per day, to reduce the risk of alcohol-related harm over a lifetime. Choose one answer.

#	Answer	%	Count
1	Two	35.24%	37
2	Three	19.05%	20
3	Four	38.10%	40
4	Not sure	7.62%	8
	Total	100%	105

Q59 - The following statements are in relation to alcohol consumption. Please select agree, disagree or not sure.

#	Question	Agree		Disagree		Not sure		Total
1	Alcohol may increase testosterone levels	17.92%	19	52.83%	56	29.25%	31	106
2	Drinking large amounts of alcohol can reduce recovery from injury	74.53%	79	15.09%	16	10.38%	11	106
3	Alcohol consumption can increase the risk of vitamin and mineral deficiencies	84.91%	90	4.72%	5	10.38%	11	106

Q60 - "Binge drinking" is generally defined as: Choose one answer.

#	Answer	%	Count
1	Having two or more standard alcoholic drinks on the same occasion	2.83%	3
2	Having four to five or more standard alcoholic drinks on the same occasion	52.83%	56
3	Having seven to eight or more standard alcoholic drinks on the same occasion	41.51%	44
4	Not sure	2.83%	3
	Total	100%	106

Appendix G. Nutrition Practices Questionnaire

Q61 - What is the most amount of weight that you have intentionally lost in one week?

#	Answer
1	1-2 lbs
2	2-3 lbs
3	4 or more lbs
4	I have never intentionally tried to lose weight.

Q62 - What is the most amount of weight that you have intentionally gained in one week?

#	Answer
1	0.5- 1 lb
2	1- 2 lbs
3	2-3 lbs
4	4 or more lbs
5	I have never intentionally tried to gain weight.

Q63 - Which of the following weight management (for weight gain, weight loss, or weight maintenance) strategies have you tried?

#	Answer
1	Low-carbohydrate diet (i.e. Ketogenic Diet, Paleo Diet, Whole30 Diet, Atkins Diet, Zone Diet)
2	Tracking calories or tracking macronutrients
3	Intermittent fasting or skipping meals
4	Sweatsuits/ saunas
5	Laxatives
6	Diuretics
7	Fasted cardio
8	Self-induced vomiting
9	Other; Please specify:
	Total

Q64 - Why did you utilize this strategy?

1	To lose weight
2	To gain weight
3	Weight maintenance
4	To pass a military fitness tet
5	To improve strength and performance
6	General health/wellness

Q65 - When did you last utilize this strategy?

1	Within the past week
2	Within the current academic semester
3	Within the past year
4	Over one year ago

Q66 - On average, how many servings of grains do you eat per day? (e.g., 1 serving= 1 slice of bread, ½ cup rice, ½ cup pasta, ¼ large bagel, 1 mini bagel, 1 packet of oatmeal, a 6" tortilla)

#	Answer
1	Less than 1
2	1-2
3	3-4
4	5-6
5	7 or more

Q68 - On average, how many cups of fruit do you eat per day? (e.g., 1 cup of fruit= 1 small apple, 1 large banana, 1 large orange, about 8 large strawberries, about 32 seedless grapes)

#	Answer
1	None
2	< 1 cup
3	1 cup- 1 ½ cups
4	1 ½ cups- 2 cups
5	2 cups or more

Q69 - On average, how many cups of vegetables do you eat per day? (e.g., 1 cup vegetables= 1 large red pepper, 1 medium potato, 1 large tomato, 1 cup chopped or cooked vegetables, 2 cups raw leafy greens)

#	Answer
1	None
2	
3	1 - 2 cups
4	2- 3 cups
5	3 cups or more

Q70 - On average, how many servings of dairy do you eat per day? (e.g., 1 serving of dairy= 1 cup milk, 1 cup yogurt, 2 slices of cheese, 1/3 cup shredded cheese)

#	Answer
1	None
2	< 1 serving
3	1-2 servings
4	2-3 servings
5	3 or more servings

Q71 - How often do you make a point to choose healthy sources of fat (omega-3 fatty acids) over foods high in saturated fat? (e.g., choosing food cooked in olive oil instead of butter, choosing a vinaigrette dressing instead of ranch, choosing a marinara sauce instead of a cream sauce, choosing peanuts instead of potato chips as a snack)

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely
5	Never

Q72 - Which of the following types of dietary supplements do you use? Check all that apply.

#	Answer
1	Multivitamin/mineral supplements
2	Individual vitamin or mineral supplements
3	Fish oil or omega-3 supplements
4	Herbal supplements (i.e. Green tea extract, Gingko Biloba)
5	Protein powders or bars
6	Creatine
7	Pre-workout supplements

8	Branched-Chain Amino Acids (BCAAs)
9	“Fat burners”/ thermogenic supplements
11	Testosterone boosters
10	Other; please specify

Q73 - Why do you use this supplement?

#	Question
1	Prescribed by a health care professional
2	General health and wellness
3	Improve physical performance
4	Increase strength
5	Gain weight
6	Lose weight
7	Physical appearance/ aesthetics
8	Convenience
9	Not sure

Q74 - Do you check for third-party testing certification (e.g., NSF or Informed Choice) before using dietary supplements?

#	Answer
1	Yes
2	No
3	I do not use dietary supplements
	Total

Q76 - I drink at least 16 fluid ounces of water (e.g., 1 standard disposable water bottle) within 4 hours before exercise.

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely
5	Never

Q77 - I drink 6-8 fluid ounces of water every 20 minutes during exercise.

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely
5	Never

Q78 - I routinely carry a water bottle and drink water consistently throughout the day.

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely
5	Never

Q79 - I weigh myself before and after exercise to determine how much water I need to drink.

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely
5	Never

Q80 - I drink a sports drink or eat salty foods after an intense workout.

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely
5	Never

Q81 - I eat before working out.

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely
5	Never

Q82 - I eat a carbohydrate-rich meal within 4 hours of beginning a workout.

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely

5	Never

Q83 - I eat a carbodhydrate-rich snack within 1 hour of beginning a workout.

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely
5	Never

Q84 - I eat protein-rich foods before strength training.

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely
5	Never

Q85 - I eat high-fat foods before endurance training.

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely
5	Never

Q86 - I consume carbohydrates (sports drinks, fruit, energy gels) during intense workouts lasting more than 75 minutes.

#	Answer
1	Always
2	Most of the time
3	Sometimes

4	Rarely
5	Never

Q87 - I consume branched chain amino acids during my workouts.

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely
5	Never

Q88 - I eat within an hour of finishing a workout.

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely
5	Never

Q90 - I consume 15-40 grams of protein after working out.

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely
5	Never

Q91 - I consume at least 15 grams of protein with every meal.

#	Answer
1	Always
2	Most of the time

3	Sometimes
4	Rarely
5	Never

Q92 - I eat large portions of meat/protein (>60 g) in a single meal (e.g., eating an 8-ounce steak).

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely
5	Never

Q93 - I make a point to eat foods high in carbohydrate after working out (e.g., rice, pasta, oatmeal, quinoa, cereal, bread, potatoes, beans, fruit).

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely
5	Never

Q94 - I eat at least three meals per day at consistent times.

#	Answer
1	Always
2	Most of the time
3	Sometimes
4	Rarely
5	Never

Q95 - During the last 12 months, how often did you usually have any kind of drink containing alcohol? One drink is considered half an ounce of absolute alcohol (e.g. a

12 ounce can or glass of beer or cooler, a 5 ounce glass of wine, or a drink containing 1 shot of liquor).

#	Answer
1	Every day
2	5 to 6 times a week
3	3 to 4 times a week
4	twice a week
5	once a week
6	2 to 3 times a month
7	once a month
8	Less than once a month

Q96 - During the last 12 months, how often did you have 5 or more (males) or 4 or more (females) drinks containing any kind of alcohol in within a two-hour period?

#	Answer
1	Every day
2	5 to 6 days a week
3	3 to 4 days a week
4	two days a week
5	once a week
6	2 to 4 days a month
7	once a month
8	less than once a month
9	never

Q97 - During the last 12 months, how many alcoholic drinks did you have on a typical day when you drank alcohol?

#	Answer
1	25 or more drinks
2	19 to 24 drinks

3	16 to 18 drinks
4	12 to 15 drinks
5	9 to 11 drinks
6	7 to 8 drinks
7	5 to 6 drinks
8	3 to 4 drinks
9	2 drinks
10	1 drink
11	I have not drank alcohol in the past 12 months