

3-6-2015

Dietary Supplement Use, Perceptions, and Associated Lifestyle Behaviors in Undergraduate College Students, Student-Athletes, and ROTC Cadets

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DIETARY SUPPLEMENT USE, PERCEPTIONS, AND ASSOCIATED LIFESTYLE
BEHAVIORS IN UNDERGRADUATE COLLEGE STUDENTS, STUDENT-
ATHLETES, AND ROTC CADETS

Arthur A. Valentine

153 Pages

May 2015

The use of dietary supplements has steadily increased among the American population in recent years; however, little is known about current trends in dietary supplement use in the collegiate population. The purpose of this study was to investigate dietary supplement use, perceptions of knowledge and efficacy of dietary supplements, and lifestyle behaviors of supplement users and non-users in a university population. Undergraduate students, NCAA division I student-athletes, and Army ROTC cadets at a midsized Midwestern University were recruited for a single-stage cross-sectional online survey via email and also through the use of fliers. Participants included 381 undergraduate students, 56 student-athletes, and 58 ROTC cadets.

Half or more of each of the surveyed population groups reported dietary supplement use. Multivitamin/mineral supplements were the most commonly used supplements in the undergraduate and student-athlete samples, while cadets most commonly reported the use of protein supplements. Chi-square analysis indicated that

undergraduate supplement users generally reported more favorable perceptions of dietary supplement efficacy for a variety of conditions compared to non-using counterparts.

Supplement users in all of the samples had very positive perceptions of the efficacy of the individual supplements they were taking. Independent sample t-tests and chi-square analysis indicated that undergraduate student supplement users reported significantly more exercise and more healthful dietary habits compared to non-users, but were also more likely to report tobacco use. Differences in lifestyle behaviors of users and non-users in the student-athlete and cadet samples were much less pronounced.

Keywords: Dietary Supplements, College Students, Student-Athletes, ROTC Cadet

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ATHLETES, AND ROTC CADETS

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A Thesis Submitted in Partial
Fulfillment of the Requirements
for the Degree of

MASTER OF SCIENCE

Department of Family and Consumer Sciences

ILLINOIS STATE UNIVERSITY

2015

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ACKNOWLEDGMENTS

I would be remiss to not first thank my beautiful and wonderfully supportive wife. Alyssa, you have provided me with unconditional support and love throughout this entire process, and I am so incredibly blessed to have you in my life. Thank you. I have the blessing of calling four different people my parents, and all of you have served as inspiration for this research and for all of my other academic endeavors. To my mother, you have never let me forget how much you love me, and I would not be half of who I am without you. To my father, you have provided me with such incredible support and invaluable advice throughout my entire life. I am incredibly blessed to call you my father as well as my friend. Lisa, you have taught me that even in our darkest days, it is never too much to reach out to others. I truly admire your perseverance as a cancer survivor. You impact so many people each and every day with your guidance and words of wisdom; please, never forget how many people are grateful for you. Jerry, you taught me the value of hard work at such a young age, and your guidance has truly helped to shape me. I am greatly appreciative of your love, guidance, and support. As always, Go Pack Go!

Donna, Eric, Gram, and Op, thank you all so very much for your love and support; I love you all. To my best friend, 2nd Lt. Joshua Houston, I am so happy that you have followed your dreams. Our country is a much safer place with people like you defending our freedom. You, like all members of our nation's armed forces, sacrifice so

much to keep us safe, and I will always be greatly appreciative of that. Thank you for your service, and never forget that you will always be my best friend.

To my wonderful grandparents, John and Anita, you have never let me forget how special I am in your eyes. I could never thank you enough for your support throughout my entire life. To my grandmother Marlene, I also thank you for all of your support, especially during my time in South Dakota. You have never hesitated to support me during my academic endeavors, and I will forever be grateful for you and your support.

To my little sister, my brother, and to my nephew Leo, please let this research be further proof that, with enough hard work and dedication, anything is possible. I ask nothing more of you than to follow your dreams (and to root for the Packers). Thank you for being a part of my life. Thanks are also due to those who have supervised and supported this research. Dr. Schumacher, thank you for your invaluable guidance and support. I have greatly enjoyed having the opportunity to learn from you. Dr. Murphy, thank you for your countless edits and for all of your advice. Dr. Ma, thank you for your statistical reinforcement and for making me a better researcher. A special thanks also goes out to Mr. Chris Carter, Lt. Col. Bender and to Dr. Kathy Beerman. Thank you all for your support throughout this process.

A.A.V

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CHAPTER I
DIETARY SUPPLEMENT USE, PERCEPTIONS, AND ASSOCIATED
LIFESTYLE BEHAVIORS IN UNDERGRADUATE STUDENTS,
STUDENT-ATHLETES, AND ROTC CADETS

Introduction

The Dietary Supplement Health and Education Act of 1994 (DSHEA) placed dietary supplements into a special category requiring that each supplement be labeled as a dietary supplement and not as a food or a drug.^{1, 2} Under the DSHEA, the corporation manufacturing and/or distributing the dietary supplement product is responsible for ensuring that supplements are safe and also that advertising is not false or misleading, thus eliminating Food and Drug Administration (FDA) approval before marketing.¹ The only exception to this rule is when a dietary supplement contains a “new dietary ingredient” that was not on the market prior to the 1994 DSHEA.^{2, 3} In this instance, the marketers must notify the FDA about their intent to distribute the new ingredient and must also provide evidence supporting the safety of the product.³ Once a supplement has been marketed, the FDA must show that the supplement is unsafe prior to taking any action to restrict its sale or to remove the product from the marketplace.^{1, 2} In other words, as stated by the *American Cancer Society’s* webpage on dietary supplements, “drugs are viewed as unsafe until proven safe” whereas “dietary supplements are viewed as safe until proven unsafe.”⁴

The FDA compiles evidence to make decisions regarding the safety of marketed supplements primarily through mandated manufacturer/distributor reporting of adverse events and also through health care provider and/or consumer reporting through the FDA's adverse event reporting portal.⁵ However, it is estimated that a small fraction of consumers who have experienced an adverse effect from a dietary supplement report such an event either to the supplement company, to a health care provider or directly to the FDA.^{6,7} Additionally, one study looking at the presence of banned drugs in dietary supplements after FDA recalls found that as many as two-thirds of recalled products remained adulterated, and readily available, at least six months after the initial FDA recall.⁸ Indeed, the dietary supplement industry's current lack of federal oversight and strict regulation has many detractors who would like to see the industry undergo more rigorous standards for both safety and efficacy to better serve the American people.⁶⁻¹¹

Although dietary supplements are not regulated as strictly as other products, consumers from various demographics believe that the products that they take are safe and/or effective for helping them to meet their goals.¹²⁻¹⁷ Most recently, a 2013 survey conducted by the Council for Responsible Nutrition (CRN) found that 85% of those polled were confident in the safety, quality and effectiveness of dietary supplements.¹⁸ The 2014 edition of the same survey found that consumer confidence had remained steady at 83%.¹⁹ While overall confidence in dietary supplements remains high, many Americans such as undergraduate students,²⁰⁻²¹ adults,²²⁻²³ and physicians²⁴ are not aware of the FDA's limited role in the testing or regulation of supplements. One study found that informing college students about the FDA's lack of approval for a fat loss supplement made the subjects less confident about the product's safety but had no

influence on perceived effectiveness.²⁰ The investigators suggested that consumers might associate FDA approval with overall safety but not with effectiveness.²⁰

Surveys show that the use of dietary supplements has become increasingly common. One investigation found that use of dietary supplements had steadily increased in the American adult population since the 1970's.²⁵ The investigators also found that the prevalence of use increased with age in both men and women and also that women aged 20-74 had the highest prevalence of supplement use in the years 1999-2000.²⁵ The Center for Disease Control (CDC) reported that an estimated 53% of American adults used at least one dietary supplement between 2003 and 2006, compared to 42% between 1988-1994, with supplement use being more common in women than in men during in both time frames.²⁶ The current percentage of Americans who use supplements may be much higher, as high as 64-69%, especially when considering those who use supplements seasonally or occasionally.^{19,27}

Dietary supplements also have a profound impact on the United States' economy. *Nutraceuticals World Magazine*, using sales data information from the *Nutrition Business Journal*, reported that the supplement industry had an estimated 32.5 billion dollars in revenue in 2012.²⁸ The industry is expected to experience continual economic growth and, according to a 2013 *Forbes Magazine* article, may exceed 60 billion dollars in revenue by the year 2021.²⁹ Additionally, the U.S. Government Accountability Office reported that there were approximately 4,000 dietary supplement products on the market in 1994 compared to an estimated 75,000 different products in year of 2008--an increase of nearly 1,900% in 14 years.^{6,7}

While there is substantial literature pertaining to the use of dietary supplements among the general adult population, recent research focusing on the collegiate population is limited. One study sampled 200 students at a university recreation center and found that 44.2% students were using a supplement at the time of study and also 58.3% of students were using, or had used, a dietary supplement.³⁰ Other studies have found supplement usage rates at 94.3%³¹ and 70.6%,³² respectively, in university student populations. Similar research exists within the student-athlete population. For example, Froiland and colleagues³³ sampled 207 university athletes and found that 89% were taking, or had taken, a dietary supplement. Similarly, Burns and associates³⁴ found that, of a sample of 236 university athletes, 88% were using at least one dietary supplement. Another study found that 98.6% of student-athletes had used at least one dietary supplement.³¹

There is an extremely limited amount of current literature focusing on supplement use in Army ROTC cadets. However, there is research pertaining dietary supplement use in other military populations. One study surveyed 329 activity duty, deployed, U.S. Marines and found that 72% of Male Marines and 42% of Female Marines had used a supplement within 30 days of taking the survey.³⁵ Austin and associates³⁶ surveyed 990 U.S. Army Soldiers and found that 70.3% had used at least one supplement within 6 months before the survey. Another study found that 53% of active U.S. Army Soldiers were taking a supplement at least one time a week during the 6 months prior to the survey.³⁷

The studies regarding dietary supplement use in college students, student-athletes and military personnel support the notion that these populations have rates of supplement

use at least equal to, but possibly higher than, estimated usage rates of the general population--where regular usage rates generally hover around 50% of those surveyed but may be as high as 69% when occasional or seasonal users are included.^{19, 27, 38-40}

Increased usage rates within the collegiate population could be multifactorial. As pointed out by Johnson and Blanchard,⁴¹ many college-aged adults use this time for experimentation and exploration. Such a desire to experiment may increase the desire to try new things, including alternative forms of medicine and health promoting activities. Additionally, many college students are concerned with body image and/or have low levels of body satisfaction.^{42- 45} This dissatisfaction may lead young adults to use dietary supplement products in an effort to increase physical appearance.

NCAA student athletes and ROTC cadets may be candidates for increased rates of dietary supplement usage for other reasons. Examples include: yearning for a competitive edge, rigorous schedules, body composition goals, physical fitness standards, or the stresses imposed by the demands of their sport or military training.^{33, 36, 46-48} Additionally, ROTC cadets may perceive some type of pressure to look a certain way given their status as a future soldier.^{36, 49,50} Supplement marketers and advertisers may also be targeting such demographics through the use of visually pleasing fitness models, paid endorsements from athletes and celebrities and/or through claims of performance/recovery enhancement or promotion of health or physical appearance.⁵¹⁻⁵³

There is also very little known about lifestyle behaviors of supplement users versus non-users in the collegiate population. In the general population, dietary supplement use has been seen to be more common in those with a healthy weight, those who partake in more physical activity, those with better overall diets, and also in those

who do not use tobacco.^{38, 40,54,55} One study found that adults who used multiple types of dietary supplements had more favorable concentrations of blood markers indicative of overall health status and lower rates of elevated blood pressure and diabetes compared to adults who took only a multivitamin and also those who were not supplement users.⁵⁶ Such findings led Dickinson and MacKay⁴⁰ to state "...the evidence indicates that users of dietary supplements tend to incorporate these products into their lifestyles as part of a broader focus on healthy living..."^(p.12)

On the contrary, Chiou, Yang and Wan⁵⁷ argued that, "The growing market for dietary supplements appears not to be associated with an improvement in public health" and also contended, "...the health credentials provided by taking dietary supplements may trigger a fundamental psychological belief in one's invulnerability...leading to engagement in health-risk behaviors..."^{57(pp.1081-1082)} The investigators proceeded with their experiment and found, true to their theory, that those subjects who were taking what they believed were dietary supplements exhibited less desire for exercise and also had greater interest in a buffet style meal over an organic, smaller, meal choice.⁵⁷

Which of these dietary supplement-overall health behavior connections (if any) are present in the college population is not entirely known. Previous research has confirmed that young adults, such as college students, are prone to engaging in health risk behaviors such as binge drinking,⁵⁸⁻⁶⁰ tobacco use,^{61,62} inadequate physical activity,^{63, 64} and less than optimal dietary habits.⁶⁵⁻⁶⁸ A propensity to engage in such behaviors make college students an interesting population for further research regarding any relationship between lifestyle behaviors and dietary supplement use. The purposes of this study were a) to identify the prevalence of, and trends associated with, dietary supplement use in an

undergraduate student population; b) to assess self-reported beliefs in the health benefits and efficacy of dietary supplements and to compare beliefs between users and non-users of dietary supplements; and c) to compare lifestyle behaviors among supplement users and non-users. This research contributed to the existing dietary supplement literature and is of use to university health departments, registered dietitian nutritionists, military leaders, and trainers.

Methods

This study received approval from the University's Institutional Review Board (IRB) for administration with human subjects. All participants were full time undergraduate students at a Midsize Midwestern University. The study population included three separate independent groups: general full-time general undergraduate students, NCAA Division I student- athletes and student Army ROTC cadets. Prior to accessing the survey, all subjects were asked to confirm that they met one of the independent group criteria and were ≥ 18 years of age. All undergraduate students, regardless of academic major and/or sport played, were eligible to participate in the study.

The initial recruitment email provided information regarding the purpose of the study, the estimated duration, the anonymity of the study and also informed participants about the randomized drawing to win one of four \$20 gift cards upon completion of the survey. An incentive was offered in an effort to increase survey participation, and sign up for the drawing was optional and not tied to the initial survey results. Subsequent email reminder messages stated the importance of the research and encouraged subjects to take the survey if they had not already done so. The subjects who had already taken the survey

were thanked and asked to disregard the email. Recruitment and data collection began in early October of 2014 when the initial recruitment email was sent to prospective participants and promotional fliers were posted around selected campus locations. A reminder email was sent out approximately three weeks after the initial recruitment email along with another reminder two weeks later.

All email recruitment and subsequent reminder messaging was performed with the help of the university's associate director of the office of infrastructure, operations and networking. Emails were sent to all students who had indicated that they were willing to receive email invitations for student research (n=13,695). The principles of Dillman, Smyth and Christian⁶⁹ were utilized in deciding the number of times to contact prospective participants. Fliers were also created to advertise the study to student-athletes and Army ROTC cadets. The fliers were designed by the study author and included much of the same content as the recruitment email including information regarding the purpose of the study, estimated length, incentives, and contact information. The fliers also advertised the complete anonymity of the survey. Both the flier tear offs and the recruitment email contained the survey URL, which directed prospective participants to the informed consent document that preceded the questionnaire. Due to a lack of participation by the student athlete population, the sports nutrition director also sent out a reminder email to all student athletes in an effort to help increase participation. This email included a description of the study, the recruitment text as well as the survey URL.

Instrument

This study used a single stage, cross sectional survey design to gather information regarding dietary supplement use, attitudes and associated lifestyle behaviors in the college population. A web-based survey design was decided upon due to cost effectiveness, relative ease of use, the ability to reach a large number of prospective participants, computer literacy of the college population, timeliness, the availability of an electronic data collection system as well as the ability to easily import data into analysis programs.^{70, 71} The instrument utilized to conduct the current study was adapted from an existing research study performed in 2001, entitled “Use of Nonvitamin, Nonmineral Dietary Supplements Among College Students.”¹⁶ The 2001 survey was chosen for modified use in the current study due to similarities in methodology and research objectives. The original questionnaire was pretested in 2001 with 15 undergraduate students to evaluate clarity and appropriateness of the subject matter.¹⁶

The 2001 instrument contained 25 questions and “assessed the extent of students’ use of NVNM (non-vitamin, non-mineral) supplements and their associated knowledge and beliefs” and included items on “gender, age, academic major, dietary adequacy, exercise patterns, ethnicity and health practices”.^{16(p.124)} Similar to the current study, the original authors asked all participants to list any supplements they had used in the 12 months prior to the survey. A significant difference, the original survey was designed to evaluate the use of non-vitamin, non-mineral dietary supplements (e.g. herbal & ergogenic) whereas the modified survey was designed to include all different types of dietary supplements including vitamins and minerals, herbal supplements and sports (ergogenic) supplements.

The original survey author responded, granted permission, and provided suggestions for modification throughout the new survey creation process via email. The original survey author ultimately approved the adapted version of the original survey for use in the current study. The final adapted survey contained some of the same questions (kept in the original format) as the 2001 survey and also featured new questions to meet the study author's current research objectives.

Demographic information collected on the survey included biological sex, self reported height & weight, current year in school towards completion of an undergraduate degree and status as an NCAA athlete or ROTC cadet. The questionnaire then focused on levels of dietary supplement knowledge and also the efficacy of supplement products. To assess dietary supplement knowledge participants were asked, "how knowledgeable are you about dietary supplements?" and were asked to respond using a 4-point Likert-type scale. Participants could choose "very knowledgeable," "somewhat knowledgeable," "not very knowledgeable," or "not knowledgeable at all." All participants were then asked to answer a series of seven questions regarding the efficacy of supplements for various conditions such as treatment or prevention of disease, fat loss and muscle building. Participants were asked to respond to each question with a "yes," "no" or "don't know" answer.

Next, the questionnaire focused on supplement use and associated information. All survey participants were provided with the legal definition of a dietary supplement defined by the United States Food and Drug Administration.⁵ Participants were asked to answer with a "yes" or a "no" to the question, "within the past 12 months, have you taken any type of dietary supplement?" Participants who answered "no" were directed to a

question asking why they hadn't taken any supplements. Answer choices for reasons for non-use included, "do not believe in them/feel there is no need," "do not know enough about them," "they seem unhealthy/unnatural/have side effects," and "cost." Participants could also type in a response using free-text. Those who reported the use of any supplement were directed to supplement use questions (bypassing the non-use question). The supplement use questions asked participants to indicate which supplements they had used, frequency of use, reasons for using that particular supplement and also to state their belief in the efficacy of the supplement. The survey included nine different supplement classes--multivitamin/mineral, singular vitamin/mineral, herbal, carbohydrate, energy, protein, creatine, dieting and pre-workout supplements. Participants were also allowed to indicate any other unlisted supplements they had used.

After the specific supplement use questions, all supplement users were asked to report the average amount of money spent per month on supplement products and also asked to list their first two greatest sources of supplement information from a list of eleven different sources (e.g. internet, friends, health professionals). Questions pertaining to the safety of supplements followed. Participants were asked about whether or not they had experienced any adverse event(s) stemming from the use of supplements. If yes, they were directed to a question pertaining to symptoms and were also asked if they had a) continued to take the supplement and b) if they had discussed their experience with a health care professional.

The last section of the survey included lifestyle behavior questions. All users, supplement user or non-user, were directed to these questions for the purpose of comparison between users and non-users. The first two questions pertained to perceived

levels of overall health and weight status. For the assessment of overall health, a 5-point Likert-type was employed. The question “which of the following best describes your overall health?” had five possible answers: “excellent,” “good,” “neutral,” “fair,” or “poor.” A one indicated “poor” and a five indicated “excellent.” The question “how do you feel about your weight? I am currently _____” had five possible responses as well. The options included: “prefer not to answer,” “underweight,” “at my desired weight,” “slightly overweight,” and “greatly overweight.”

To assess physical activity behaviors, all participants were asked, “over the past seven days, how many times did you engage in moderate or higher intensity cardiovascular activity?” Participants were also asked the same question but instead for strength training as opposed to cardiovascular activity. Examples for each type of activity (cardio and strength) were provided and responses were on a 0-7 day continuous scale. To assess diet behaviors, the survey asked about daily fruit and vegetable consumption, frequency of breakfast intake and also self-reported diet quality. Self-reported diet quality was also measured using a 5-point Likert-type scale, where a one indicated “poor” and a five indicated “excellent.”

To assess alcohol behaviors, participants were asked to disclose their average number of alcoholic drinks consumed per week, average number of days per week of alcohol consumption and the average number of days per week of binge drinking. Tobacco consumption was assessed by asking all participants, “have you used any tobacco product within the past year?” If yes, participants were asked to state their frequency of tobacco consumption. For clarification purposes, the questionnaire included various definitions to help the user determine the most appropriate answer for select

questions. Provided definitions included fruit and vegetable servings as defined by the United States Department of Agriculture,⁷³ alcohol servings as defined by the Academy of Nutrition and Dietetics,⁷⁴ and the definition of binge drinking as defined by the National Institute of Alcohol Abuse and Alcoholism.⁷⁵

Online survey creation principles from Schonlau, Fricker and Elliott⁷⁶ were used as a guide for creating a user-friendly online survey. The study author focused on listing only a few questions per screen to limit excessive scrolling, the use of “radio buttons” to limit participant’s responses to one choice for select questions, and only required answers on rare occasions when necessary to trigger a conditional page.⁷⁶ Similar to the original 2001 study, most questions were formatted as closed forced choice responses with the exception of the questions regarding perceived efficacy of dietary supplements, which allowed a “not sure” answer option. The final survey contained a total of 79 possible questions, although many questions were conditional based on prior responses.

In order to gauge the effectiveness and user-friendliness of the study instrument, pilot testing was performed in late summer of 2014. Four different open text comment boxes were placed within the survey asking the pilot testers to comment on clarity, structure and effectiveness of the survey to that point. Ten prospective pilot testers, all of whom were full-time undergraduate students from institutions separate from the study university, were contacted via email and asked for their honesty in assessing the overall clarity and effectiveness of a thesis survey. Of the 10 students contacted, eight responded and pilot tested the survey. The testers provided feedback and suggestions for improvement through the open text comment boxes. Suggestions were taken into consideration and some changes were made to enhance the overall clarity and ease of use.

The time that it took each participant to take the survey was also averaged to calculate the estimated time of completion that was reported in the final recruitment message and informed consent document.

Data Analysis

All data was collected using an online survey system (Select Survey, Illinois State University). After collection, all data was exported to Microsoft Excel (Version 14.4.4) and then into SPSS version 22 (Chicago, Illinois). Incomplete surveys were not included in the final analysis procedures. Descriptive statistics including frequency distributions and cross tabulations were used to describe population characteristics, patterns of supplement use, and associated information within each targeted population (general undergraduate students, student-athletes & Army ROTC cadets). For statistical analysis, chi-square (χ^2) tests of independence and Fisher's exact tests (for analysis with low expected cell counts) were used to test for relationships between categorical data. Independent t-tests were employed to test for significant differences with continuous data (e.g. physical activity, diet and alcohol behaviors) and the use or non-use of dietary supplement products within each independent population. All data was considered statistically significant at $p < .05$.

Results

Undergraduate Sample

Of the 485 undergraduate students who entered the survey, 381 (76.9%) completed the survey and were included for analysis. See Table 1 for comparisons between the undergraduate sample and the undergraduate population at the surveyed university.

Overall, 58% of undergraduate students (n=221) reported dietary supplement (DS) use. Undergraduate DS users reported using an average of 6.48 (SD=4.58) different supplements, and most commonly reported using 1-4 different DS in the 12-month period preceding the survey (Table 2). Over 63% of male and 54.9% of female undergraduates reported DS use; however, this difference was not significant (Table 2). DS use was most common among 5th year undergraduates (85.7%), and was least common in 1st year undergraduates (43.8%). These observed differences were significant, χ^2 (5, N=381) =27.27, $p<.001$ (Table 2). DS use was most common in undergraduates who were classified as obese (71%) and least common in underweight students (35.7%). The differences in supplement use by body mass index (BMI) were also significant, χ^2 (3, N=381) =13.37 $p=.004$ (Table 2).

Undergraduates who reported no DS use most commonly listed their reasoning for non-use as “do not know enough about them (supplements)” (n=91). Alternatively, undergraduate DS users reported many different reasons for DS use, with “good health/illness prevention” being most commonly reported (Table 3a). Undergraduate student DS users (n=221) most commonly reported the use of multivitamin/mineral supplements (MVM) (n=197, 89.1%) and least commonly reported the use of creatine

(n=38, 17.2%) (Table 4a) Undergraduate DS users had the highest belief in the effectiveness of pre-workout DS (96.7%), and were least confident in the efficacy of weight loss DS. (Table 4a). Additionally, users of protein DS most commonly reported the use of whey protein (n=89, 71.2%), and singular vitamin/mineral (VM) users most commonly reported the use of Vitamin C (n=76, 51%).

To analyze the use of individual supplements by participant characteristics, only those who reported DS use were included for analysis (n=221). In the undergraduate student DS user sample, male DS users were significantly more likely than female DS users to have used carbohydrate DS, $\chi^2(1, N=221) = 5.559, p = .018$; energy DS, $\chi^2(1, N=221) = 4.638, p = .031$; protein DS, $\chi^2(1, N=221) = 9.994, p = .002$; creatine, $\chi^2(1, N=221) = 54.621, p = .000$; and pre-workout DS, $\chi^2(1, N=221) = 25.192, p < .001$. Analysis also indicated that there was no significant association between lower (1st and 2nd year) or upper (3rd-non-traditional) class status and the use of any individual type of DS. However, overweight/obese undergraduate DS users were more likely to have taken creatine, $\chi^2(1, N=221) = 10.357, p = .001$; weight loss DS, $\chi^2(1, N=221) = 5.287, p = .021$; and pre-workout DS, $\chi^2(1, N=221) = 8.570, p = .003$ compared to underweight/normal counterparts. Of note, for analysis of individual DS use by BMI in the undergraduate sample, underweight and normal were combined, while overweight and obese were also combined due to low expected cell counts. Furthermore, 1st and 2nd year students were combined to form “lower” class and 3rd-non-traditional were combined to form “upper” class for the same reason.

Over two-thirds of undergraduate DS users (n=174, 78.7%) reported spending <\$50.00 per month, while thirty-four (15.4%) reported spending \$50.00-99.99 per month,

and thirteen (5.9%) reported spending >\$100.00 a month on DS. Undergraduate DS users most commonly reported the Internet as a source of DS information (n=86, 38.9%); only nine respondents (4.1%) listed a registered dietitian (RD) as a source of DS information (Table 5). Nearly 30% of DS users (n=66) reported the discontinuation of DS. Those who had discontinued a supplement most commonly reported discontinuation due to ineffectiveness (n=30). Just over 17% of undergraduate DS users (n=38) reported experiencing an adverse event related to DS use (Table 6). Of those who reported an adverse event(s), nearly half (n=17, 44.7%) reported that they had continued taking the DS thought to have been responsible, while just over one-third (n=14, 36.8%) reported discussing their experiences with a health care professional. Those who had not discussed their experiences (n=24, 63.2%) most commonly reported not feeling as though a discussion was important as their reason for a lack of discussion (n=15, 62.5%).

Looking at overall perceptions of DS efficacy and knowledge in the undergraduate sample, undergraduate students were the most confident in the efficacy of DS for health and wellness promotion (74%), followed by muscle building (62.5%), physical performance enhancement (58%), disease prevention (47.8%), fat loss (47.8%), physical appearance enhancement (47%), and disease treatment or control (44.1%). Additionally, undergraduate students most commonly reported being “somewhat knowledgeable” about dietary supplements (46%), followed by “not very knowledgeable” (31.8%), “very knowledgeable” (12.3%), and “not knowledgeable at all” (9.4%).

Comparisons of efficacy and knowledge beliefs by status as a DS user or non-user indicated that DS users were significantly more likely than non-users to believe in the

efficacy of DS for disease prevention, χ^2 (2, N=378) =25.121, $p<.001$; disease treatment or control, χ^2 (2, N=379) =15.570, $p<.001$; health and wellness promotion, χ^2 (2, N=378) =35.462, $p<.001$; physical performance enhancement, χ^2 (2, N=379) =20.203, $p<.001$; muscle building, χ^2 (2, N=379) =15.564, $p<.001$; and physical appearance enhancement, χ^2 (2, N=380) =13.996, $p=.001$ (Table 7). Additionally, DS users were significantly more likely to report being “somewhat knowledgeable,” or “very knowledgeable” about DS compared to non-users, χ^2 (3, N=380) =95.091, $p<.001$ (Table 7).

Analysis of lifestyle behaviors by status as a DS user or non-user indicated that undergraduate DS users had a significantly higher average self-reported health score than non-users, $t=-3.345$, $df=311.007$, $p=.001$. Undergraduate DS users also reported more cardiovascular activity, $t=-2.537$, $df=378$, $p=.012$; strength training, $t=-6.15$, $df=377.9$, $p<.001$; higher levels of fruit and vegetable, $t=-2.548$, $df=369$, $p=.011$; and breakfast consumption, $t=-3.202$, $df=379$, $p=.001$; and a more positive perception of their overall diet quality, $t=-3.560$, $df=379$, $p<.001$ (Table 8). There were no significant differences in alcohol behaviors between users and non-users in the undergraduate population. Alternatively, DS use was significantly more common among undergraduates who reported tobacco use compared to those who reported no tobacco use, χ^2 (1, N=381) =9.217, $p=.002$ (Table 8).

Student-Athlete Sample

Of the 71 student-athletes who entered the survey, 56 completed the survey and were included for analysis (78.9%). Refer to Table 1 for comparisons between the student-athlete sample and the student-athlete population at the surveyed university.

Over half of student-athlete respondents (n=30, 53.6%) reported supplement use. Student-athlete DS users (n=30) reported taking an average of 7.1 (SD=3.37) different supplements, and most commonly reported using 5-10 different DS (Table 2). DS use was significantly more common among male student-athletes, with 71.4% of male and 42.9% of female student-athletes reporting use, $\chi^2 (1, N=56) = 4.308, p = .038$ (Table 2). DS use was most commonly observed in 1st year (64.7%), and least commonly seen in 2nd year student-athletes (41.2%); however, this finding was not statistically significant (Table 2). For the purpose of analyzing DS use by BMI status, the one student-athlete classified as underweight was collapsed into the normal category and the five student-athletes classified as obese were collapsed into the overweight category to alleviate low cell counts. There was no significant association between BMI (underweight/normal vs. overweight/obese) and overall DS use in the student athlete sample (Table 2).

Non-users in the student-athlete sample most commonly listed their reason for non-use as a lack of DS knowledge (n=19), followed by a lack of belief in the efficacy of DS (n=11). Student-athlete DS users reported many different reasons for DS use, and these reasons are featured in Table 3b. Student-athlete DS users most commonly reported taking MVM (n=28, 93.3%) and least commonly reported the use of weight loss DS (n=2, 3.6%) (Table 4b). One hundred percent of those who used weight loss products, creatine, pre-workout DS, or herbal/botanicals believed in the effectiveness of such DS, while only 70% of those who used energy supplements believed in the efficacy of such products (Table 4b). Additionally, student-athlete singular VM users most commonly reported vitamin C or vitamin D supplements (both n=13), while protein users most commonly reported whey protein (n=23), followed by protein bars (n=19).

In the student-athlete DS user group (n=30), male DS users were significantly more likely than female users to have taken creatine supplements, $p=.042$; however, there was no significant association between gender and the use of any other individual DS. To analyze any potential relationship between individual supplement use and year towards completion of a degree, 1st and 2nd year student-athletes were collapsed into a “lower” class group, while 3rd and 4th year student-athletes were collapsed into an “upper” class group. There was no significant association between “upper” or “lower” class standing and the use any individual DS in the student-athlete sample. However, overweight/obese supplement users were more likely to use creatine than their underweight/normal counterparts, $p=.047$. Of note, weight loss DS were excluded from analysis in the student-athlete sample due to only two respondents reporting the use of such products. Both of the weight loss supplement users were 3rd year males; one user was classified as normal weight, and the other user was classified as obese. Additionally, analyses of multivitamin/mineral use by year in school and also by BMI were not reported due to cell minimum expected counts of .80 and .73, respectively.

Twenty-four student-athletes (80%) reported spending <\$50.00 per month on DS, while three (10%) reported spending between \$50.00-99.99 per month, and three others (10%) reported spending >\$100.00. Student-athletes most commonly listed an athletic trainer/coach (n=24, 80%) as a source of information, while only one student-athlete (3.3%) listed an RD as a source of information (Table 5). Eleven of the 30 supplement users (36.6%) reported discontinuing the use of at least one DS. The most common reasons for discontinuation were due to ineffectiveness (n=6) and no longer needing the DS (n=6). Only one student-athlete supplement user (3.3%) reported an adverse event;

the student-athlete reported experiencing skin irritation, fever, nausea/vomiting, increased heart rate and headaches. The student-athlete did not continue taking the supplement and did not discuss the adverse reactions with a healthcare professional.

Overall, student-athletes were most confident in the efficacy of DS for health/wellness promotion (69.6%), followed by physical performance enhancement (51.8%), muscle building (53.6%), physical appearance enhancement (53.6%), disease prevention (46.4%), fat loss (44.6%), and disease treatment/control (41.1%). Furthermore, student-athletes most commonly reported being “somewhat knowledgeable” about DS (44.6%), followed by “not very knowledgeable” (37.5%), “not knowledgeable at all” (8.9%), and “very knowledgeable” (8.9%) about DS.

For comparisons of efficacy and knowledge beliefs between student-athlete DS users and non-users, those who selected “don’t know” for an efficacy question were excluded from analysis, while knowledge levels were collapsed into “knowledgeable” or “not knowledgeable” due to low expected cell counts. Both of these measures were performed to allow for Fisher’s exact testing. Analysis indicated that student-athlete DS users were significantly more likely than non-users to believe in the efficacy of supplements for disease treatment or control, $p=.014$; overall health and wellness promotion, $p=.047$; and helping to maximize physical performance, $p=.017$ (Table 7). Additionally, student-athlete DS users were more likely to report being knowledgeable about DS compared to non-users, $\chi^2(1, N=56)=7.01, p=.008$ (Table 7).

Lifestyle behaviors of student-athlete users and non-users are featured in Table 8. In summary, student-athlete DS users reported a significantly higher average dietary adequacy/quality score than non-users, $t=-2.113, df=54, p=.039$, but did not significantly

differ in any other lifestyle behavior. Of note, DS use was reported by 87.5% of those who reported tobacco use compared to 47.9% of those who reported no tobacco use. Analysis indicated that this finding approached significance with $p=.056$ (Table 8).

ROTC Sample

Of the 65 ROTC cadets who progressed past the informed consent page, 58 were included for analysis (89%). Refer to table 1 for comparisons between the ROTC sample and the cadets at the surveyed university.

Exactly half of cadets ($n=29$) reported supplement use. Cadet DS users ($n=29$) reported using an average of 8.31 ($SD=4.68$) different supplements and most commonly reported using 5-10 different supplements (Table 2). There was no significant association between gender and overall DS use in the ROTC sample (Table 2). For analysis of supplement use by year in school, two categories were created to alleviate low expected cell counts; “lower” class included first and second year students, and “upper” class included third year or higher students. Exactly half of lower class students ($n=16$) and half of upper class students ($n=13$) reported DS use (Table 2). To analyze DS use by BMI classification in the ROTC sample, one underweight cadet was collapsed into the normal category, while one obese participant was collapsed into the overweight category. Analysis indicated no significant association between BMI and overall DS use in the ROTC sample (Table 2).

Cadets who reported no supplement use ($n=29$) most commonly indicated “do not know enough about them” ($n=12$) and “do not believe in them/feel there is no need” ($n=11$) as reasons for non-use. “Cost” had six responses, while “they seem unhealthy/unnatural/have side effects” had four responses. Alternatively, cadet DS users

reported many different reasons for DS use; Table 3c features reasons for using individual types of DS in the cadet sample. ROTC DS users most commonly reported the use of protein DS (n=25, 86.2%) and least commonly reported the use of herbal DS (n=2, 3.4%) (Table 4c). Additionally, 100% of cadet protein or weight loss DS users believed in the efficacy of such products, while neither of the cadet botanical users (n=2) believed in the efficacy of botanicals (Table 4c). Cadet protein DS users most commonly reported the use of whey protein (n=25, 100%), followed by protein bars (n=17, 68%), and branched chain amino acids (n=10, 40%). Cadets who reported use of singular VM products most commonly used Vitamin C (n=13, 72.2%), followed by vitamin D, (n=7, 38.9%) and vitamin B₁₂ (n=7, 38.9%).

Fisher's exact testing indicated that male DS users were significantly more likely to use creatine than were female users, $p=.044$. Additionally, "upper" class DS users (3rd year or higher) were more likely to use both creatine, $\chi^2 (1, N=29) 5.673, p=.017$; and pre-workout supplements, $\chi^2 (1, N=29)=4.507, p=.034$ compared to "lower" class cadet DS users (1st and 2nd year). However, there was no association between BMI status (normal vs. overweight/obese) and the use of any individual types of DS in the cadet sample. Of note, botanical supplements were excluded from the above analysis due to only two cadets reporting use of such supplements. Both botanical DS users were 1st year males; one botanical user was of normal BMI, while the other was classified as overweight.

Over half of Cadet DS users reported spending <\$50.00 per month (n=18, 62%), while ten (34.4%) reported spending \$50-99.99 per month on DS. Cadet DS users most commonly listed the Internet as a source of DS information (n=13, 44.8%), while only

two cadets (6.9%) listed an RD as a source of DS information (Table 5). Nine DS users (31%) reported discontinuing the use of at least one supplement. Those who had discontinued most commonly indicated their reasoning as “too expensive” (n=5), while two reported, “felt the supplement(s) were ineffective.” Three of the twenty-nine cadet DS users (10.3%) reported an adverse event. All three reported an increased heart rate as one of their symptoms, while two reported sleep disturbances, and two reported headaches. Other reported symptoms included skin irritation, chest pain, and gastrointestinal distress. Two-thirds of cadets who had experienced an adverse event continued to take the product deemed responsible and no cadets reported such event(s) to a physician. When asked why, one participant checked “it only happened once/don’t feel that it’s important to discuss,” another cadet responded “consulted friends first,” while the third cadet responded, “don’t feel that it’s important to discuss.”

Overall, ROTC cadets were most confident in the efficacy of DS for health and wellness promotion (82.7%), followed by physical performance enhancement (75.9%), muscle building (77.6%), and physical appearance enhancement (50%). Twenty-eight cadets (48.3%) each reported a positive efficacy belief for disease prevention, disease treatment/control, and fat loss. Furthermore, over half (56.9%) of cadets reported that they were “somewhat knowledgeable” about dietary supplements. Just over a quarter of ROTC cadets (25.9%) reported that they were “not very knowledgeable,” while three cadets (5.2%) reported being “not knowledgeable at all,” and seven cadets (12.1%) reported being “very knowledgeable.”

For comparisons of efficacy and knowledge beliefs between cadet DS users and non-users, those who selected “don’t know” for an efficacy question were excluded from

analysis so as to allow for Fisher's exact tests, while knowledge levels were collapsed into "knowledgeable" or "not knowledgeable" for the same reason. Cadet users and non-users did not significantly differ in their beliefs regarding the efficacy of supplements for any of the conditions listed (Table 7). Additionally, there was no significant association between DS use and self-reported supplement knowledge in the ROTC sample (Table 7). Cadet DS users reported a significantly higher frequency of strength training than non-users, $t=-2.310$, $df=56$, $p=.025$; however, there were no other significant differences in lifestyle behaviors between users and non-users in the cadet sample (Table 8).

Comment

Our findings indicated that dietary supplements (DS) were used by greater than or equal to half of undergraduate students (58%), student-athletes (53.6%), and ROTC cadets (50.0%). The observed DS prevalence in our sample of undergraduate students was lower than other studies,^{31,32,41,77,78} but was higher than others^{16, 79,80} and was nearly the same to the findings of another.³⁰ It must be noted that study objectives and methodology differed between previously conducted studies and the current research. For instance, Stasio and colleagues³² asked students about DS use in the week preceding the survey. Johnson and Blanchard⁴¹ inquired solely about herbal DS use. Lieberman et al⁷⁸ asked for use in the six-month period preceding the survey, while studies conducted by Perkin et al,⁷⁹ Newberry et al,¹⁶ and Ayranci, Son and Son⁸⁰ inquired solely about the use of non-vitamin non-mineral (NVNM) DS. In contrast, our study inquired about all DS use in a twelve-month period preceding the survey. Similar methodological differences exist between our study and previous studies conducted in student-athletes and military personnel as well.

Our finding that 53.6% of NCAA student-athletes reported DS use was lower than previously conducted studies in student-athlete samples.^{31, 33, 34,81,82} Our sample of ROTC cadets reported substantially lower rates of DS use than the findings of Stasio et al,³² who included a subgroup of 21 cadets and found that 85.7% reported DS use; however, our findings were higher than older studies conducted in military cadets.⁸³⁻⁸⁵ Cadet DS use was also lower than results from active duty military samples,^{12,36,37} but was the exact same (50%) as a study conducted in young-adult (mean age: 19) Marine recruits.⁴⁸ Our results in the ROTC sample indicated that young military cadets may use supplements to a lesser degree than their active-duty counterparts. These findings are also similar to the results of a recent meta-analysis performed by Knapik and colleagues,⁸⁶ who briefly speculated that lower prevalence of DS use by officers in training could be due to them eating in military dining facilities and having busy training schedules. Future research should focus on how the transition from cadet to an active-duty officer influences DS use.

Undergraduate student and student-athlete DS users most commonly reported the use of multivitamin/mineral supplements (MVM), similar to previous findings in the student^{26,30,78} and also student-athlete^{34,81,87} groups. Singular vitamin/mineral (VM) use was also common among our sample. The vast majority of our respondents reported the use of such products for “good health/illness prevention.” The fact that many of our respondents from each group reported the use of MVM and/or VM products for that reason was not surprising; however, the use of such supplements may be unnecessary for most, as there is little research supporting the health benefits of MVM or singular VM products in well-nourished individuals.^{89,90} While the use of such products may not produce any harm in most individuals,⁹⁰ all students should strive to consume a

nutritionally complete diet to provide themselves with the vitamins, minerals and other nutrients needed for good health and illness prevention. Health professionals working with university students should routinely emphasize the importance of a well-rounded diet as the primary source for nutritional needs.

Participants in all groups also commonly reported the use of protein supplements. Protein supplements were the most commonly reported product in our cadet sample; a finding similar to other DS studies in military samples.^{12, 48} Those who used protein DS frequently listed reasons for use such as “muscle recovery,” “bodybuilding,” and/or “increase athletic performance.” Evidence has indicated that protein is an important nutrient for muscle recovery and growth, and also that protein DS can be an effective and convenient way to increase protein intake if needed.⁹¹⁻⁹⁴ The International Society of Sports Nutrition (ISSN) position stand on protein and exercise⁹³ indicated that while athletes should first attempt to obtain protein needs by whole foods, protein supplements are also a practical way to meet protein needs.⁹³

Respondents also reported the use of other sport-supplements including stimulant-type products and creatine. Male DS users were significantly more likely than female DS users to have used creatine in each of our samples, similar to previous findings in students,³⁰ student-athletes,^{31,33} and military personnel.⁴⁸ Whether or not creatine is safe for use and/or effective has been a point of contention for many years⁹¹; however, the ISSN position stand on creatine supplementation⁹⁵ indicated that creatine has been shown to be safe and effective if used within established guidelines.⁹⁵ Similarly, creatine was listed as a supplement that “performs as claimed” in a joint position statement focusing on nutrition and performance co-authored by the American Dietetic Association (now

Academy of Nutrition and Dietetics), Dietitians of Canada, and the American College of Sports Medicine.⁹⁶

The same cannot necessarily be said about the efficacy and/or safety of commercially available stimulant-based products (i.e. energy drinks and “pre-workout” products). A 2013 report from the *Substance Abuse and Mental Health Services Administration*⁹⁷ indicated that emergency room visits involving energy drink consumption more than doubled from 2007 to 2011 and most commonly involved 18-25 year olds.⁹⁷ The ISSN position stand on energy drinks⁹⁸ indicated that energy drink products do commonly contain mental and physical performance-enhancing ingredients supported by literature such as caffeine and carbohydrate; however, the authors also indicated that much less is known about the numerous other ingredients found in such products and further study is warranted to examine their safety and/or effectiveness.⁹⁸ Additionally, “pre-workout” DS products often contain many different stimulant-type ingredients in combination and also list a “proprietary blend” that does not disclose the amounts of each ingredient to the consumer.⁹⁹ Independent analysis of pre-workout products has also indicated that some products contain dangerous, banned, illegal, unlisted and/or completely untested ingredients.^{9,100,101}

Fifteen percent of DS users (n=42) reported experiencing an adverse event as the result of taking DS. Included in this number were 38 undergraduates, three cadets and one student-athlete. Other studies in the college samples reported adverse events at 8.4%,⁸⁰ 14%,¹⁶ and 15.5%³¹ of users, indicating that our results were similar to what has typically been found. While we did not explicitly ask participants to disclose which product(s) they deemed responsible for their experience(s), it is interesting to note that of

those who reported adverse events, just over 76% (n=32) reported the use of some type of stimulant product (e.g. energy supplement, weight loss product and/or pre-workout DS). Additionally, the most commonly reported side effects in our sample were gastrointestinal distress (n=20) and increased heart rate (n=16), both of which are among the adverse effects associated with stimulant supplements as reported by Eudy et al.⁹⁹

A potential cause for concern is that only a third of those who reported an adverse event (n=14) reported their event to a health care professional while nearly half (n=19) continued to take the DS deemed responsible for their symptoms. As noted by Quinones, Winsor, Patino and Hoffmann,⁷ the reporting of an adverse event to the Food and Drug Administration (FDA) is imperative because the regulation of DS safety is largely dependent on post-market reports of adverse reactions from marketers, consumers and/or health care professionals. As such, any DS user who has experienced an adverse event should discuss such an event with their healthcare provider and also report the event directly to the FDA. Additionally, dietitians, athletic trainers, strength coaches, and ROTC leaders should be aware of how to report adverse events to the FDA in case any student decides to discuss their experiences with them. The portal can be accessed at: <http://www.fda.gov/Food/DietarySupplements/ReportAdverseEvent/default.htm>. Adverse events can also be reported to the FDA by calling 1-800-FDA-1088.

Over half of participants from each sample reported being either somewhat or very knowledgeable about supplements. Additionally, in both the undergraduate and student-athlete samples, DS users were significantly more likely than non-users to report being somewhat or very knowledgeable about DS. These findings could indicate that many who choose to use DS research DS information prior to use. Of potential concern,

undergraduate and ROTC DS users commonly reported the Internet as a source of DS information, similar to other studies in collegiate^{30, 31, 78} and military¹² samples. This finding is also in line with the predictions of Escoffery et al¹⁰² who, in 2004, predicted, “College students’ growing use of the Internet to obtain health information is likely to continue.”^{102 (p.187)} Students who choose to utilize the Internet for DS information should be directed to the FDA’s “Tips for Dietary Supplement Users” webpage, which provides consumers with information on how to make informed decisions while searching for supplement information online. There are additional resources available for the military personnel, such as the Department of Defense’s *Human Performance Research Center*. This free resource is available at: <http://hprc-online.org/dietary-supplements>.

The Internet was not nearly as popular in our student-athlete sample, which is similar to other studies.^{33, 34, 87} Instead, athletic trainers/coaches were by far the most common information source. Burns and associates³⁴ found that student-athletes perceived athletic trainers to be very knowledgeable about DS and very commonly turned to such professionals for DS information. A recent study¹⁰³ indicated that athletic trainers and strength and conditioning specialists had adequate nutrition knowledge; however, the authors point out that these professionals should turn to a registered dietitian (RD) when “situations arise beyond their scopes of practice.”^(p.205) Student-athletes should also be made aware of their ability to access the *Resource Exchange Center*. This free online resource can help student-athletes to make more informed decisions regarding supplementation and can be accessed at: <http://www.drugfreesport.com/rec/>.

Our study also found that users of individual supplements had generally favorable perceptions regarding the efficacy of the products they chose to take. In both the

undergraduate and student-athlete samples, no DS had less than 70% of users report positive beliefs regarding the product's efficacy. In the cadet sample, only two respondents reported botanical consumption, and neither user viewed their botanical products as effective; however, no other type of DS had less than 75% of users report a positive efficacy belief. In comparison, Newberry et al¹⁶ found that 77.8% of undergraduate NVNM DS users believed in the efficacy of the DS they were taking; Burns et al³⁴ found that student-athlete DS users had a moderate level of perceived efficacy of their DS, while Cassler et al³⁵ found that 81% of active-duty Marines reported noticing an improvement in physical performance as a result of DS use. Our results also indicated that undergraduate DS users were significantly more likely to report a positive efficacy belief for every DS efficacy question other than fat loss (our results in the student-athlete and cadet samples were much less pronounced). Previous studies in undergraduate samples have also indicated that DS users generally report more favorable perceptions of DS for varying conditions compared to non-users.^{16, 80}

Our third and final research objective was to determine whether or not DS users and non-users significantly differed in selected lifestyle behaviors. Our results from the undergraduate sample indicated that DS users had significantly higher measures of positive health attitudes and behaviors including self-reported health scores, exercise patterns and dietary behaviors. Our finding that undergraduate DS users typically reported overall healthier lifestyles than their non-user counterparts is similar to findings in adult samples^{39, 40} and further supports the "inverse supplement hypothesis" proposed by Kirk and associates,^{104, 105} which states, "...the people most likely to use dietary supplements may be those who least need them."^{104 (p.69)}

Additionally, our finding that DS users engaged in physical activity more frequently than non-users was similar to other studies in the young adult¹⁰⁶ and college samples,^{79,80} suggesting that young adult/college aged DS users make more of an effort to engage in physical activity relative to those who do not use DS. Of interest, our findings also indicated that DS use was most common in obese undergraduates and that nearly 72% of those who reported tobacco use within the past 12 months also reported DS use. Our finding that DS use was very common in undergraduate tobacco users was similar to previous studies in the young adult/collegiate samples,^{78-80,106} and further supports the hypothesis proposed by Perkin et al,⁷⁹ that “one explanation for (DS) usage among student smokers is that (DS) usage could be viewed as offsetting a negative behavior (i.e. smoking).”^{79 (p.414)} Certainly, campus health professionals should be aware that tobacco users may use DS in a perceived effort to lessen the damage done by tobacco use and efforts to promote smoking cessation should be implemented.

Our finding that DS use was most common in overweight/obese undergraduates was an interesting finding and is generally dissimilar to findings in adult samples.^{39, 40} A previous study⁸⁰ found NVNM DS use to be most common in students at the extremes of the body mass index (BMI) scale (underweight and obese); however, our finding that the prevalence of DS use increased as BMI increased is unique. One possible explanation could be that many DS users in the overweight or obese classifications had high levels of skeletal muscle mass through increased rates of physical activity (and possibly through the use of DS). Skeletal muscle mass is not taken into consideration with the BMI equation, so those who exercise more frequently may have higher BMIs due to increased levels of muscle mass.¹⁰⁷ Admittedly, this explanation is purely speculative. Further

research should be conducted to investigate the possible relationship between increasing BMI and DS use in collegiate samples.

A potential concern with our undergraduate sample was that the use of weight loss DS was least common in obese students (n=8, 15.1%), and was highest in normal weight (n=23, 43.9%), followed by overweight (n=22, 41.5%) students. Why students of a normal weight were the group most likely to report weight loss DS is unknown, and is dissimilar to the findings of a study examining weight loss DS use in an adult sample.¹⁰⁸ The evidence supporting the efficacy of many commercially sold weight-loss DS is limited at best,^{109,110} and some products are tainted with prescription grade pharmaceuticals and/or controlled substances that may pose a risk to consumers.¹¹¹ All students, regardless of BMI, should be encouraged to adopt an overall healthy lifestyle primarily focusing on a balanced, nutritious, diet and ample physical activity. An RD in conjunction with an exercise professional can help students set realistic goals to achieve a healthy weight through diet and exercise, and the use of such trained professionals should be encouraged on college campuses.

We observed very few differences in lifestyle behaviors in the student-athlete and cadet samples. Cadet DS users reported significantly more strength training compared to non-users, similar to findings in active-duty Army DS users.³⁷ Additionally, student-athlete DS users had a significantly higher self-reported dietary quality score compared to non-users. This finding may indicate that student-athletes who use DS also make a conscious effort to ensure a balanced diet. However, research has indicated that many student-athletes have less than adequate nutrition knowledge and may not fully understand what constitutes a healthy diet.^{103, 112, 113} To enhance nutrition knowledge,

student-athletes should be provided with nutrition education through the use of strategies including (but not limited to): cooking demonstrations and discussions, tours through campus dining facilities and grocery stores, and other basic nutrition presentations focusing on a healthy diet for sports performance and overall health.

Limitations

This study has potential limitations that should be noted. All data was self-reported. Such self-reporting may prompt an innate bias from respondents, and there is no way to ensure that all participants were being completely honest about their answers. While we made every effort to stress complete anonymity on both the recruitment email and informed consent document, some participants still may not have felt comfortable disclosing their honest answers to some of the questions. This may have especially been the case with questions regarding alcohol consumption. It can be safely assumed that many of our respondents were under the legal drinking age (<21), and some may not have felt comfortable declaring true alcohol consumption habits.

Our relatively small sample size from both the undergraduate and student-athlete groups is may also be a limitation. Our sample represented just over 2% of the undergraduate student body at the study university, while our student-athlete sample represented just over 13% of the student-athletes on campus. These small sample sizes may limit our ability to generalize the results.

Another potential limitation was the way that we asked participants about their overall dietary supplement use. We provided all respondents with the Food and Drug Administration's (FDA) official definition of a dietary supplement and then asked them to report whether or not they had taken any type of supplement within the past 12

months. It is possible that some respondents did not fully understand the definition of a dietary supplement after reading the definition, and/or did not read the definition either at all or in its entirety. Since we conditionally linked all of the individual supplement questions to the overall use question, it is not beyond the realm of possibility that some respondents incorrectly answered “no” to the overall supplement use question, and thus completely avoided all of the subsequent supplement use questions that followed. An improved study design would ask all respondents to affirm that they a) read through the definition of a dietary supplement; and b) understood the definition to the fullest of their ability. Such a change could possibly improve the accuracy of the survey.

The length of the survey may also have been a limitation. While our pilot testers were able to complete the survey in roughly 15 minutes and none indicated that they believed the survey was too lengthy, we noticed that many participants dropped out or ended the survey over the course of taking it. This was especially the case during the latter portion of the survey (lifestyle questions). With that being said, there is a chance that some respondents who completed the survey became fatigued at some point during the survey.

Conclusions

Although limitations do exist for this research, our findings provide further information regarding dietary supplement use, perceptions of efficacy, and lifestyle behaviors of users and non-users of supplement products. Previous research has focused on dietary supplement use in various populations, but this was the first study to focus on dietary supplement use and efficacy/knowledge perceptions in the three different independent populations chosen here. Additionally, prior to this research study, there was

very little current research regarding lifestyle behaviors of supplement users and non-users in college samples. This research objective, and our subsequent results, helped to fill that void in the literature. This study indicated that at least half of respondents from each of our independent groups (students, student-athletes and Army ROTC cadets) reported dietary supplement use and also that supplement users reported a wide variety of reasons for using individual types of supplements.

These results also indicated that some users experienced adverse events from dietary supplement use, which is consistent with the results of other studies. Our discussion pointed out that there are many reputable resources available to dietary supplement users. Those who use supplements would be wise to make use of such resources and would also be wise to report any and all adverse events to their healthcare provider and to the Food and Drug Administration (FDA). Health professionals who work with college students should be aware of the availability of reputable resources and should also be aware of how to report adverse events to the FDA.

These findings suggest that college students, especially those who choose to use supplements, have quite favorable perceptions about dietary supplement products for various conditions. While the available literature does support the efficacy and overall safety of certain products, there is very limited research available on many others. Campus health professionals should ensure that supplement users have realistic expectations for the products that they choose to take. Our study also found that the lifestyle behaviors of dietary supplement users and non-users differed the most in the undergraduate student population. This finding may be due in part to undergraduate

college students having more freedom to choose their lifestyle behaviors (e.g. physical activity frequency) than those involved in athletics or in an ROTC program.

**Table 1.
Demographic Information of Respondents**

	Undergrad (n=381)	University (n=17,028)	Student- Athletes (n=56)	University (n=418)	ROTC Cadets (n=58)	University (n=132)
Gender						
Male	35.4%	44.8%	37.5%	56.5%	65.5%	68.1%
Female	64.6%	56.2%	62.5%	43.5%	34.5%	31.9%
Class						
1st	27.6%	27.5%	30.4%	23.9%	39.7%	56.1%
2nd	15.2%	19.9%	30.4%	24.2%	15.5%	8.3%
3rd	21.3%	24.8%	19.6%	20.8%	22.4%	17.4%
4th	22.3%	27.4%	19.6%	31.1%	15.5%	16.7%
5th	7.3%				5.3%	
6th	0.3%					
Other	6.0%				1.7%	
BMI						
Underweight	3.7%		1.8%		1.7%	
Normal	58.8%		62.5%		58.6%	
Overweight	29.4%		26.8%		37.9%	
Obese	8.1%		8.9%		1.7%	

Table 2.

Characteristics of Dietary Supplement Users and Non-Users

Characteristics	Undergraduates			Student-Athletes			ROTC Cadets		
	Users (n=221)	Nonusers (n=160)	<i>p</i>	Users (n=30)	Nonusers (n=26)	<i>p</i>	Users (n=29)	Nonusers (n=29)	<i>p</i>
Gender									
Male	63.7%	36.3%	.095(NS) §	71.4%	28.6%	.038§§	55.3%	44.7%	.269(NS)§§§
Female	54.9%	45.1%		42.9%	57.1%		40.0%	60.0%	
Year in School									
1 st	43.8%	56.2%	<.001 ^ε	64.7%	35.3%	.592 (NS) ^{εε}			
2 nd	72.4%	27.6%		41.2%	58.8%		50.0%	50.0%	1.000(NS) ^{εεε}
3 rd	59.3%	40.7%		54.5%	45.5%		50.0%	50.0%	
4 th	49.3%	50.7%		54.5%	45.5%				
5 th	85.7%	14.3%							
6 th /Non-trad	75.0%	25.0%							
Body Mass Index (BMI) ^ο									
Underweight	35.7%	64.3%	.004 ^φ						
Normal	52.2%	47.8%		52.8%	47.3%	.873 (NS) [£]	45.7%	54.3%	.421(NS) ^{££}
Overweight	68.8%	31.2%		55.0%	45.0%		56.5%	43.5%	
Obese	71.0%	29.0%							
Number of DS taken									
1-4	41.6%			23.3%			20.7%		
5-10	41.2%			56.7%			55.2%		
11-14	10.4%			20.0%			13.8%		
15-20	5.5%			0.0%			6.9%		
20 or more	1.8%			0.0%			3.4%		

NS=Not significant at the $p < .05$ level; § χ^2 (1, N=381) = 2.787, $p = .095$; ^ε χ^2 (5, N=381) = 27.273, $p < .001$; ^φ χ^2 (3, N=381) = 13.367, $p = .004$; ^{§§} χ^2 (1, N=56) = 4.308, $p = .038$; ^{εε} χ^2 (3, N=56) = 1.91, $p = .592$; ^ο Collapsed into “underweight/normal” (N=36) and “overweight/obese” (N=20) for student-athlete analysis; [£] χ^2 (1, N=56) = .026, $p = .873$; χ^2 (1, N=58) = 1.221, $p = .269$; ^{εεε} [Collapsed into “lower” (1st-2nd) and “upper” (3rd-non traditional)], χ^2 (1, N=58) = .000, $p = 1.000$; ^{££} [One underweight cadet collapsed into normal, one obese cadet collapsed into overweight], χ^2 (1, N=58) = .648, $p = .421$

Table 3a.
Reasons for Dietary Supplement Use in the Undergraduate Sample

Reasons	MVM [∞]	VM [§]	Protein	Energy	CHO [¶]	Pre-Workout	Dieting	Herbals	Creatine
	(n=197)	(n=149)	(n=125)	(n=124)	(n=104)	(n=61)	(n=53)	(n=51)	(n=38)
Good Health/Illness Prevention	181	119	59	3	25	3	9	26	1
Increased Energy	70	61	33	112	49	56	19	9	11
Prevent Depression	0	14	0	2	0	1	3	5	0
Prevent Headaches	14	10	0	8	3	1	0	2	0
Anxiety Relief	21	13	2	4	1	0	1	5	0
Mind, Brain Benefits	0	26	5	17	3	5	3	0	2
Immunity	86	57	9	1	5	0	1	17	0
Pregnancy	0	1	0	0	0	0	0	0	0
Prevent Cancer	11	4	0	0	0	0	0	1	0
Endocrine Function	0	8	2	0	0	0	0	0	0
Skin, Hair and Nails	78	46	5	0	1	0	2	4	0
Anemia	10	7	1	0	0	0	0	1	0
Joint Pain	26	13	4	0	0	0	1	3	0
Muscle Recovery	55	16	67	4	31	19	1	3	23
Vascularity	36	10	16	9	7	28	2	4	8
Reduce Muscle Pain	25	11	28	6	6	5	2	5	6
Weight Loss	36	11	35	11	7	7	53	10	4
Bodybuilding	43	16	64	10	22	23	3	2	34
Athletic Performance	39	13	48	22	32	42	8	2	8
Improved Sleep	42	23	3	2	2	0	1	5	0
Increased Intake	43	18	22	0	8	0	1	2	2
Other	4	0	2	2	18	0	0	4	0
Participants were allowed to list as many reasons for use as applied									
∞=Multivitamin/mineral; §=Singular Vitamin/Mineral supplements; ¶=Carbohydrate supplements									

Table 3b.
Reasons for Dietary Supplement Use in the Student-Athlete Sample

Reasons	MVM [∞]	Protein	CHO [¶]	VM [§]	Energy	Pre-Workout	Creatine	Herbals	Dieting
	(n=28)	(n=27)	(n=24)	(n=24)	(n=10)	(n=7)	(n=5)	(n=3)	(n=2)
Good Health/Illness Prevention	25	16	6	23	1	1	3	3	2
Increased Energy	7	0	13	11	11	6	2	0	2
Prevent Depression	3	0	0	2	0	0	0	0	0
Prevent Headaches	3	0	1	0	0	0	0	0	0
Anxiety/Stress Relief	3	0	0	1	1	0	0	2	0
Mind, Brain Benefits	0	0	1	4	1	1	0	0	0
Immunity	10	0	0	8	1	0	0	1	0
Pregnancy	0	0	0	0	0	0	0	0	0
Prevent Cancer	2	0	0	2	0	0	0	0	0
Endocrine Function	0	0	0	1	0	0	0	0	0
Skin, Hair and Nails	24	2	0	5	0	0	0	1	0
Anemia	3	0	0	5	0	0	0	0	0
Joint Pain	9	1	0	3	0	0	0	0	0
Muscle Recovery	11	22	11	5	0	1	3	1	1
Vascularity	4	8	0	3	0	2	2	1	1
Reduce Muscle Pain	4	8	1	3	0	0	0	0	0
Weight Loss	2	5	0	2	0	0	0	1	1
Bodybuilding	8	14	1	2	0	1	2	0	0
Athletic Performance	8	20	14	7	1	3	1	1	1
Improved Sleep	7	1	0	3	0	0	0	0	0
Increased Intake	5	0	1	0	0	0	1	0	0
Other	0	1	1	0	0	0	0	0	0

Participants were allowed to list as many reasons for use as applied.

∞=Multivitamin/mineral; §=Singular Vitamin/Mineral supplements; ¶=Carbohydrate supplements

Table 3c.
Reasons for Dietary Supplement Use in the ROTC Cadet Sample

Reasons	Protein	Energy	MVM ∞	VM \S	Pre-workout	CHO	Creatine	Dieting	Herbals
	(n=25)	(n=24)	(n=22)	(n=18)	(n=16)	(n=14)	(n=13)	(n=6)	(n=2)
Good Health/Illness Prevention	13	1	18	16	0	4	0	11	1
Increased Energy	9	22	9	8	14	9	3	11	0
Prevent Depression	0	0	1	0	1	0	0	0	0
Prevent Headaches	0	1	0	1	0	0	0	0	0
Anxiety Relief	0	1	0	0	0	0	0	0	0
Mind, Brain Benefits	0	1	0	0	0	0	0	0	0
Immunity	0	1	5	6	0	1	0	0	0
Pregnancy	0	0	0	0	0	0	0	0	0
Prevent Cancer	0	0	0	0	0	0	0	0	1
Endocrine Function	2	0	0	1	0	0	0	0	1
Skin, Hair and Nails	0	0	3	3	0	0	0	0	1
Anemia	0	0	1	0	0	0	0	0	0
Joint Pain	1	0	3	3	0	0	2	0	1
Muscle Recovery	1	1	13	4	4	8	10	0	0
Vascularity	4	2	7	2	8	1	2	0	0
Reduce Muscle Pain	10	0	7	3	2	0	4	0	0
Weight Loss	4	2	6	2	1	0	1	4	0
Bodybuilding	21	0	11	4	3	4	8	0	0
Athletic Performance	17	3	13	4	10	8	11	1	0
Improved Sleep	2	0	0	1	0	0	0	0	0
Increased Intake	7	0	0	0	0	1	1	0	0
Other	0	0	0	0	0	1	0	0	0

*Participants were allowed to list as many reasons for use as applied

∞ =Multivitamin/mineral; \S =Singular Vitamin/Mineral supplements; ¶=Carbohydrate supplements

Table 4a.
Dietary Supplement Use, Frequency of Use and Efficacy Beliefs in the Undergraduate Sample

DS	<i>n</i>	%£	%¶	Daily	Weekly	Monthly	<1x/month	Other	EfficacyΦ
MVM∞	197	51.7%	89.1%	156	18	4	10	9	85.0%
Singular VM§	149	39.1%	67.4%	86	33	14	9	7	96.0%
Protein	125	32.8%	56.6%	65	30	11	10	9	95.2%
Energy DS	124	32.5%	56.1%	28	36	21	32	7	85.2%
Carbohydrate	104	27.3%	47.1%	29	31	14	23	7	78.9%
Pre-workout	61	16.0%	27.6%	35	14	4	3	5	96.7%
Weight Loss	53	13.9%	23.9%	32	11	1	5	4	70.0%
Herbals	51	13.4%	23.1%	24	8	5	9	5	74.5%
Creatine	38	10.0%	17.2%	29	4	1	2	2	92.1%
∞=Multivitamin/mineral;§=Singular Vitamin/Mineral supplements									
£ Percentage of respondents who reported the use of each individual supplement (n=381)									
¶ Percentage of DS users who reported use of each individual supplement (n=221)									
All frequency of use information (daily, weekly etc.) is expressed as the number of users who reported each frequency									
ΦPercentage of individual DS users who reported a belief in the efficacy of such DS									

Table 4b.									
Dietary Supplement Use, Frequency of Use and Efficacy Beliefs in the Student-Athlete Sample									
DS	<i>n</i>	% [£]	% [¶]	Daily	Weekly	Monthly	<1x/month	Other	Efficacy ^Φ
MVM[∞]	28	50.0%	93.3%	20	7	1	0	0	92.8%
Protein	27	48.2%	90.0%	14	10	1	1	1	92.6%
Singular VM[§]	24	42.9%	80.0%	14	9	0	0	1	95.8%
Carbohydrate	24	42.9%	80.0%	8	11	4	1	1	92.0%
Energy	10	17.9%	33.3%	0	3	2	5	0	70.0%
Pre-workout	7	12.5%	23.3%	2	5	0	0	0	100.0%
Creatine	5	8.9%	16.7%	3	2	0	0	0	100.0%
Herbals	3	5.4%	10.0%	0	1	2	0	0	100.0%
Weight Loss	2	3.6%	6.7%	1	1	0	0	0	100.0%
∞=Multivitamin/mineral; §=Singular Vitamin/Mineral supplements									
£ Percentage of respondents who reported the use of each individual supplement (n=56)									
¶ Percentage of DS users who reported use of each individual supplement (n=30)									
All frequency of use information (daily, weekly etc.) is expressed as the number of users who reported each frequency									
ΦPercentage of individual DS users who reported a belief in the efficacy of such DS									

Table 4c.									
Dietary Supplement Use, Frequency of Use and Efficacy Beliefs in the ROTC Sample									
DS	<i>n</i>	%£	%¶	Daily	Weekly	Monthly	<1x/month	Other	EfficacyΦ
Protein	25	43.1%	86.2%	14	9	0	1	1	100.0%
Energy	24	41.4%	82.8%	5	8	4	4	3	95.8%
MVM∞	22	37.9%	75.9%	14	3	2	3	0	95.0%
Singular VM§	18	31.0%	62.1%	12	5	1	0	0	94.4%
Pre-workout	16	27.6%	55.2%	8	5	1	1	1	81.3%
Carbohydrate	14	24.1%	48.3%	5	6	2	1	0	93.0%
Creatine	13	22.4%	44.8%	8	3	1	0	1	92.3%
Weight Loss	6	10.3%	20.7%	5	1	0	0	0	100.0%
Herbals	2	3.4%	6.9%	0	0	0	1	1	0.0%
∞=Multivitamin/mineral;§=Singular Vitamin/Mineral supplements									
£ Percentage of respondents who reported the use of each individual supplement (n=58)									
¶ Percentage of DS users who reported use of each individual supplement (n=29)									
All frequency of use information (daily, weekly etc.) is expressed as the number of users who reported each frequency									
ΦPercentage of individual DS users who reported a belief in the efficacy of such DS									

Table 5. Sources of Dietary Supplement Information			
Sources	Undergraduates (n=221)	Student- Athletes (n=30)	ROTC (n=29)
Internet	86	5	13
Labels on Containers	69	3	4
Health Care Professional	60	4	4
Family Members	53	7	3
Store Sales Associate	40	4	9
Friends	38	3	11
Athletic Trainer/Coach	24	24	10
Television	9	0	0
Registered Dietitian	9	1	2
Magazine	4	0	0
Books	4	0	0
Academic Journals	3	0	0
College Curriculum	3	0	0
All DS users were asked to list their top two sources of DS information; some participants only listed one reason.			

**Table 6.
Adverse Reactions in the Undergraduate Sample**

Adverse Event	<i>n</i>
Gastrointestinal Stress	19
Increased Heart Rate	12
Anxiety	12
Sleep Disturbances	11
Headaches	9
Fever, Nausea, and/or Vomiting	8
Skin Irritation	5
Increased Blood Pressure	5
Chest Pain	3
Muscle Soreness	1
Erectile Dysfunction	1
Lightheadedness	1
Neon Yellow Urine	1
Acne	1

38 undergraduates reported an adverse reaction as the result of DS consumption. Participants were allowed to choose as many adverse reactions as applied and were also allowed to write in their own adverse event experiences.

Table 7.
Perceptions of Dietary Supplement Efficacy and Knowledge

Efficacy or Knowledge Beliefs	Undergraduates			Student Athletes			ROTC Cadets		
	Users (n=221)	Nonusers (n=160)	<i>p</i>	Users (n=30)	Nonusers (n=26)	<i>p</i>	Users (n=29)	Nonusers (n=29)	<i>p</i>
<u>Disease Prevention</u>									
Yes	70.9%	29.1%	<.001 ^ε	80.8%	19.2%	.093(NS) ^{εε}	57.1%	42.9%	.141(NS) ^{εεε}
No	44.6%	55.4%		40.0%	60.0%		30.0%	70.0%	
Don't Know	46.0%	54.0%							
<u>Disease Treatment/Control</u>									
Yes	68.5%	31.5%	<.001 [§]	82.6%	17.4%	.014 ^{§§}	50.0%	50.0%	1.000 (NS) ^{§§§}
No	55.4%	44.6%		28.6%	71.4%		44.4%	55.6%	
Don't Know	45.4%	54.6%							
<u>Health and Wellness</u>									
Yes	66.7%	33.3%	<.001 ^ε	66.7%	33.3%	.047 ^{εε}	56.3%	43.8%	.583(NS) ^{εεε}
No	42.2%	57.8%		25.0%	75.0%		33.3%	66.7%	
Don't Know	25.5%	74.5%							
<u>Physical Performance</u>									
Yes	67.4%	32.6%	<.001 [†]	71.9%	28.1%	.017 ^{††}	59.1%	40.9%	.082(NS) ^{†††}
No	43.8%	56.2%		22.2%	77.8%		16.7%	83.3%	
Don't Know	44.9%	55.1%							
<u>Muscle Building</u>									
Yes	65.5%	34.5%	<.001 [‡]	66.7%	33.3%	.287 (NS) ^{‡‡}	57.8%	42.2%	.227(NS) ^{‡‡‡}
No	41.3%	58.8%		45.5%	54.5%		28.6%	71.4%	
Don't Know	52.5%	47.5%							
<u>Fat Loss</u>									
Yes	62.1%	37.9%	.103 (NS) ^β	56.0%	44.0%	.870 (NS) ^{ββ}	60.7%	39.3%	.157(NS) ^{βββ}
No	58.6%	41.4%		53.3%	46.7%		40.0%	60.0%	
Don't Know	48.2%	51.8%							
<u>Physical Appearance</u>									
Yes	68.2%	31.8%	.001 ^γ	66.7%	33.3%	.174 (NS) ^{γγ}	69.0%	31.0%	.065(NS) ^{γγγ}
No	48.5%	51.5%		41.7%	58.3%		42.1%	57.9%	
Don't Know	50.7%	49.3%							
<u>DS Knowledge</u>									
Not at all	5.6%	94.4%	<.001 ^ϛ						
Not Very	39.7%	60.3%		34.6%	65.4%	.008 ^Ϟ	38.9%	61.1%	.256(NS) ^{ϞϞ}
Somewhat	71.6%	28.4%		70.0%	30.0%		55.0%	45.0%	
Very	93.6%	6.4%							

“Don't Know” respondents were excluded in athletes and ROTC samples. ^ε χ^2 (2, N=378) = 25.12, $p < .001$; [§] χ^2 (2, N=379) = 15.57, $p < .001$; ^ε χ^2 (2, N=378) = 35.46, $p < .001$; [†] χ^2 (2, N=379) = 20.20, $p < .001$; ^β χ^2 (2, N=379) = 15.56, $p < .001$; ^γ χ^2 (2, N=380) = 13.996, $p = .001$; ^{εε} (N=31, $p = .093$); ^{§§} (N=31, $p = .014$); ^{εε} (N=47, $p = .047$); ^{††} (N=41, $p = .017$); ^{‡‡} (N=41, $p = .287$); ^{ββ} χ^2 (1, N=40) = .027, $p = .870$; ^{γγ} (N=42, $p = .174$). ^{εεε} χ^2 (1, N=38) = 2.171, $p = .141$; ^{§§§} (N=37, $p = 1.000$); ^{εεε} (N=51, $p = .583$); ^{†††} (N=50, $p = .082$); ^{‡‡‡} (N=52, $p = .227$); ^{βββ} χ^2 (1, N=48) = 2.006, $p = .157$; ^{γγγ} χ^2 (1, N=48) = 3.41, $p = .06$; ^ϛ χ^2 (3, N=380) = 95.091, $p < .001$; ^Ϟ χ^2 (1, N=56) = 7.01, $p = .008$ [student-athletes collapsed into “not knowledgeable” or “knowledgeable.”]; ^{ϞϞ} [Cadets collapsed into “not knowledgeable” or “knowledgeable.”]; χ^2 (1, N=58) = 1.289, $p = .256$.

Table 8.
Lifestyle Behaviors of Supplement Users and Non-Users

Characteristics	Undergraduates			Student-Athletes			ROTC Cadets		
	Users (n=221)	Nonusers (n=160)	p	Users (n=30)	Nonusers (n=26)	p	Users (n=29)	Nonusers (n=29)	p
Health Score[‡]	4.07 ± 0.76	3.78 ± 0.89	.001 [‡]	4.38±.56	4.32 ± .56	.699(NS) ^{‡‡}	4.31±0.54	4.00± .80	.90(NS) ^{‡‡‡}
Weight Perception									
Underweight	54.8%	45.2%	.242 (NS) [§]			.642(NS) ^{§§}	58.3%	41.7%	.779(NS) ^{§§§}
At desired weight	56.4%	43.6%		51.4%	48.6%		50.0%	50.0%	
Slightly Overweight	57.7%	42.3%		57.9%	42.1%		45.8%	54.2%	
Greatly Overweight	78.3%	21.7%							
Cardio Activity Freq.	2.67 ± 1.98	2.15 ± 1.99	.012 [¶]	5.07±1.99	5.12± 2.13	.924(NS) ^{¶¶}	4.31±1.54	4.28±1.77	.937(NS) ^{¶¶¶}
Strength Train Freq.	2.41 ± 2.26	1.19 ± 1.63	<.001 [‡]	3.90 ± 1.37	3.23 ± 1.77	.118 (NS) ^{‡‡}	4.21 ± 1.78	3.17±1.63	.025 ^{‡‡‡}
Fruit and Vegetables	3.25 ± 1.56	2.83 ± 1.62	.011 [‡]	3.83 ± 1.72	3.12 ± 1.58	.112 (NS) ^{‡‡}	3.14±1.46	2.45±1.88	.124(NS) ^{‡‡‡}
Breakfast	5.26 ± 2.16	4.51 ± 2.35	.001 [‡]	6.07 ± 1.41	5.42 ± 1.30	.08(NS) ^{‡‡}	5.31±1.65	4.72±2.34	.276(NS) ^{‡‡‡}
Dietary Quality[‡]	3.40 ± 1.09	2.99 ± 1.10	<.001 [‡]	3.80 ± .714	3.35 ± .892	.039 ^{‡‡}	3.28±.960	2.97±1.15	.269(NS) ^{‡‡‡}
# Alcoholic Drinks (per week)									
0	51.9%	48.1%	.488(NS) ^λ	54.2%	45.8%	.491(NS) ^{λλ}	40.0%	60.0%	.185(NS) ^{λλλ}
1-4	60.2%	39.8%		45.0%	55.0%		57.6%	42.4%	
5-8	65.5%	34.5%							
9-12	66.7%	33.3%							
13-15	57.1%	42.9%							
16 or more	66.7%	33.3%							
Alcohol Consumption (Days/week)	1.33 ± 1.35	1.08 ± 1.35	.082(NS) ^α	.97±.99	.92±.94	.867(NS) ^{αα}	1.38±1.15	.86±.88	.059(NS) ^{ααα}
Binge Drinking (Days/week)	.65 ± .882	.54 ± .958	.257 (NS) ^ψ	.53 ± .82	.42±.81	.615(NS) ^{ψψ}	.62±1.12	.48±.69	.573(NS) ^{ψψψ}
Tobacco Consumption									
Yes	71.9%	28.1%	.002 ^ρ	87.5%	12.5%	.056(NS) ^{ρρ}	66.7%	33.3%	.089(NS) ^{ρρρ}
No	53.8%	46.2%		47.9%	52.1%		42.5%	57.5%	

NS=Not significant at the p< .05 level; [‡]Likert-type scale (1-5) where 1=poor and 5=excellent; [‡]t=-3.35, df=311, p=.001 (equal variances not assumed); [§]χ² (3, N=375)=4.19, p=.242; [‡]t=-2.537, df=378, p=.012; [‡]t=-6.15, df=377.9, p=<.001 (equal variances not assumed); [§]t(-2.548, df=369, p=.011); [‡]t(-3.202, df=379, p=.001); [‡]t(-3.560, df=379, p=<.001); ^λ“21 or more” collapsed into “16-20” to create “16 or more,” χ² (5, N=380)=4.44, p=.488; [‡]t=-1.74, df=379, p=.082; [‡]t(-1.14, df=378, p=.257); ^ρχ² (1, N=381)=9.22, p=.002; [‡]t(-.389, df=52, p=.699); ^{§§}student-athlete weight status collapsed into “greatly/slightly overweight” vs. “under/at desired weight,” χ² (1, N=56)=.216, p=.642; ^{¶¶}t(-.096, df=53, p=.924); ^{‡‡}t(-1.590, df=54, p=.118); ^{‡‡}t(-1.614, df=54, p=.112); ^{‡‡}t(-1.763, df=54, p=.084); ^{‡‡}t(-2.113, df=54, p=.039); ^{λλ}student-athletes collapsed into “non-drinker” (0 drinks), “light drinker” (1-4 drinks), and “moderate drinker” (5-15 drinks), ^{λλ}χ² (2, N=56)=1.422, p=.491; [‡]t(-.168, df=54, p=.867); ^{ρρ}(N=56, p=.056); ^{§§§}χ² (1 or more drinks)=.500, p=.779; ^{ρρρ}t(-.079, df=56, p=.937); ^{‡‡‡}t(-2.310, df=56, p=.025); ^{‡‡‡}t(-1.560, df=56, p=.124); ^{‡‡‡}(equal variances not assumed; t=-1.101, df=50.279, p=.276); ^{‡‡‡}t(-1.116, df=56, p=.269); ^{λλλ}[collapsed into “non-drinker” (0 drinks) and “drinker” (1 or more drinks)], ^λχ² (1 or more drinks)=1.758, p=.185; ^{ααα}t(-1.931, df=56, p=.059); ^{ψψψ}t(-.567, df=56, p=.573); ^{ρρρ}χ² (1 or more drinks)=2.900, p=.089

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CHAPTER II

EXTENDED REVIEW OF THE LITERATURE

Dietary Supplement Use In Adult Samples

Gahche et al,¹ using data from National Health and Nutrition Examination Surveys (NHANES) ranging from 1988 to the year 2006, reported that dietary supplement use has become increasingly common among American adults. As compiled from NHANES data, dietary supplement use was reported by 53% of surveyed American adults between the years of 2003 and 2006,¹ compared to 52% in 1999-2000.² Additionally, approximately 40% of Americans between the years of 1988 and 1994 reported supplement use,³ compared to 28-43% of the adult population in the 1970's.⁴⁻⁶ Bailey et al⁴ reported that multivitamins were the most commonly used dietary supplement according to NHANES 2003-2006 data; this finding is in accordance with other studies that have attempted to identify trends in supplement use.^{2, 7-9} While NHANES data provides adequate information to determine overall prevalence of supplement use, the survey may not depict the most accurate picture as it only asks for supplement use within a 30-day period prior to the survey.¹⁰ Such a survey method does not necessarily capture seasonal or occasional use.^{7, 10}

To remedy this potential limitation, consumer surveys administered by the Council for Responsible Nutrition (CRN) from the years 2007-2011 asked participants about regular use in addition to seasonal or occasional use of dietary supplements.^{7, 10}

The surveys found that around 50% of respondents considered themselves regular users, and the prevalence of supplement use jumped to near 66% when occasional or seasonal users were included.^{7, 10} The results of these surveys indicated that two-thirds of the adult population use dietary supplements at some point during the year. Also reported by Dickinson and MacKay,¹⁰ the use of dietary supplements tend to increase with age and is generally higher in women compared to men within each individual age group; other existing research tends to support this conclusion.^{2,4,9,11-13} For instance, Kennedy, Luo and Houser¹² performed logistic regression on data from the 2007-2008 NHANES and found that being female and also of older age was associated with a greater likelihood of supplement use. Bailey et al,⁴ using NHANES 2003-2006 data, found that 53% of women compared to 44% of men reported supplement use. Multivitamin use was the most common among subjects ≥ 51 years of age, indicating that older adults use such products more than younger Americans.⁴ NHANES 2003-2006 data also showed that 45% of subjects aged ≤ 50 had used a supplement while 67% of those >50 years of age had used a supplement of any type.^{4, 11}

Foote et al,⁹ using data from the *Multi-Ethnic Cohort Study*, found that 56% of women and also 48% of men reported regular supplement use. Additionally, within gender specific ethnic groups, supplement use generally increased with age. Consistent with the findings of Foote et al,⁴ using NHANES 1999-2000 data, Radimer et al² found that nearly 57% of women and 47% of men had used a dietary supplement within 30 days prior to the survey. In terms of supplement use by age, 63.3% of those aged ≥ 60 reported supplement use compared to 56% of those aged 40-59 and 43% of those aged 20-39.² Using the same NHANES 1999-2000 data, Dickinson & Mister found that 45% of adults

aged ≤ 50 had used a supplement compared to 60% of adults aged ≥ 50 .^{2,11} Another study, performed by Satia-Abouta et al,¹³ utilized data from the *Vitamins and Lifestyle* (VITAL) study and found that use of dietary supplements was reported by 75% of those over the age of 50, and also that use was more common in women and generally increased with age. The results of the studies presented above provide evidence that supplement use is common among American adults, and also that supplement use is more common among females and generally increases with age.

Dietary Supplement Use In Adolescent Samples

There is also pertinent research regarding the use of supplements in children and adolescents. Evans et al¹⁴ sought to assess self or parental-reported dietary supplement use for sports performance using data from the 2007 National Health Interview Survey (NHIS) for children <18 years old. Using this data of 9,417 respondents (mean user age=10.8 years) the authors found that 1.64% of surveyed children reported using at least one dietary supplement to enhance sport performance within 30 days of taking the survey. Of those taking supplements, 94.5% of were taking a multivitamin and/or mineral combination. Fish oil use was reported by 43.5% of users, while creatine was the third most commonly reported supplement with 34.1% of affirmative respondents reporting use. Contrary to consistent findings of adult studies, supplement use was significantly more common in males compared to females (OR=2.1; 95% CI [1.3,3.3]).¹⁴

The findings presented above pertain only to respondents who answered “yes” to a question regarding use of a dietary supplement for the purposes of enhancing sport performance.¹⁴ Wu, Wang and Kennedy¹⁵ analyzed the answers to a question posed to parents (or other proxy) on the 2007 NHIS/Complimentary Alternative Medicine Survey

(CAM) for children <18 which asked, "...During the past 12 months, has [Insert Name] taken any herbal supplements listed on this card?" The authors were looking to determine the overall prevalence of herbal and non-vitamin/mineral (NVNM) dietary supplement usage among children and adolescents aged 4-17. The authors found that 3.9% of children and adolescents had used an herbal or dietary supplement in the 12 months prior to the study. Use was more common (5.4%) in subjects who were 13-17 years of age and was also slightly more common in males (4.0%) compared to females (3.8%). Similar to the findings of Evans et al,¹⁴ the most commonly reported dietary supplement was Echinacea (35.3%), followed by fish oils (29.7%).¹⁵

Other research has found higher rates of supplement use in the adolescent population, especially in adolescents who had participated in varying levels of athletics. Researchers in the Division of Adolescent Medicine at the University of Rochester¹⁶ surveyed 1,280 adolescents aged 14-19 years old. The authors included vitamin supplements on the survey, but did not include the use of such products for analysis. The investigators found that 46.2% of respondents had used dietary supplements at some point in their lifetime, and also found that 29.1% of participants had used at least one supplement in the month prior to the survey.¹⁶ Lifetime and current supplement use was more common in females (49.9 % and 31.5%) compared to males (42.7% and 26.9%) and was more common in the 16-17 year old age group (56% and 34%) compared to 14-15 year olds (35.5% and 26.1%) and 18-19 year olds (47.3% and 27.1%). Among the most commonly reported dietary supplements were ginseng, zinc, echinacea, ginko biloba, weight loss products and creatine.¹⁶

Looking at Olympic-level German adolescent athletes, Diehl et al¹⁷ found that 91.1% of a sample of 1,138 elite adolescent athletes (aged 14-18) took one or more dietary supplements at least once a month and 26.8% of those surveyed were daily supplement users. Similar to the findings of Evans and colleagues,¹⁴ male athletes were more likely than female athletes to use supplements ($p=.015$). Among monthly users, the most commonly reported supplements included magnesium, dextrose, energy drinks, vitamin C and calcium. Among daily users the most commonly used supplements were magnesium, vitamin C, iron, calcium and energy drinks. Use was more common as age increased; however, the authors deemed this finding as insignificant. Among supplement users, the main sources of information regarding supplementation were coaches (36.5%), family (20.3%), physicians (16.4%), and nutritionists (13.9%).¹⁷

Focusing on adolescents at a vocational high school, Herbold et al¹⁸ surveyed 362 high school students to ask about supplement use, physical activity, and sources of supplement information. Just fewer than 75% of students reported use, while 78% of students who participated in strength training activities reported use, and 54% of students participating in team sports reported supplement use. The authors found that there was a direct correlation between the number of supplements used and the number of team sports played ($p=.03$). Additionally, supplement use was more common in boys and girls who participated in sports compared to their same gender non-athlete counterparts.¹⁸

The authors also had students self report a height and weight for BMI calculations and found that 85% of students at a BMI level greater than the 85th percentile (by age and gender) took supplements to decrease weight and body fat. Overall, the most commonly used supplements were vitamin C, multivitamins, vitamin A, ginseng, omega 3 fatty

acids, amino acids, and creatine. Nearly half of adolescents (47.7%) reported their family as their primary source of supplement information. Only 5.8% of students reported that their coach was their source of supplement information.¹⁸

Scofield and Unruh¹⁹ surveyed 139 high school athletes and found that dietary supplement use was highest among those students who competed in two or more sports; these findings are similar to those of Herbold et al.¹⁸ Overall, 22.3% of student athletes reported taking at least one dietary supplement and 27.3% reported taking dietary supplements in the past. Similar to other findings in the adolescent population^{14, 15, 17} use was more common in males compared to females. The most commonly reported dietary supplements were meal replacement products (23.7%), vitamin and minerals (19.4%), and creatine (16%). Of those planning to play college sports, 26% were using dietary supplements. This was higher than supplement use rates in those who responded “no” to playing collegiate sports and also those who were “unsure.” Similar to the findings of Diehl et al,¹⁷ 32% of users reported that their coach was their most trusted source of information regarding supplementation.¹⁹

Dietary Supplement Use in Collegiate Samples

Some research regarding supplement use on college campuses is available. Jackson et al²⁰ set out to determine rates of supplement use, money spent per month, and sources of supplement information in a group of 200 university recreation center users. The authors proclaimed “...with hundreds to thousands of students using each university recreation facility weekly, a likely captive market for the supplement industry exists...”^{20(p.3)} The study found that 44.2% of those surveyed were taking at least one dietary supplement at the time of the study. By gender, 55.7% of male respondents and 28.6% of

female respondents were using a supplement. When considering the percentage of those who were current users or had used a dietary supplement at some point in their lives, use jumped to 58.3% of total students. By gender, 77.4% of males and 32.1% of females reported supplement use at some point in their lives. Nearly 70% of males spent over \$10 a month on supplements, and roughly 25% of males spent more than \$50 a month on supplements. Ninety percent of females spent less than \$50 a month on supplements.²⁰

Continuing with the findings of Jackson et al,²⁰ the most commonly reported supplement was a vitamin/mineral for both males and females. Protein and creatine were commonly used in the male population, while females were more likely to take diet or energy supplements. The most common sources of information were advice from a fitness instructor (25.8%) and the Internet (24.5%). The authors noted that these findings should be taken into consideration and that “weight room staff should... be educated on their legal and ethical limitation on providing this type of information to patrons.”^{20(p.7)} Also noted was the fact that Internet sources are unregulated, which was a potential concern among the authors. The authors stated that it “may be beneficial to consistently provide patrons with Internet resources that are nonbiased and educational.”^{20(p.7)} The finding that the Internet was a popular source of supplement information was in line with research published by Escoffery et al²¹ who found that college students are likely to turn to the Internet for health related information. The findings of Jackson et al²⁰ reveal that past and/or present supplement use is common in participants using campus recreation facilities, especially among male patrons.

Another study²² was administered to gauge the prevalence of over the counter (OTC) medication and/or dietary supplement use in 201 college students. The study

found that 70.6% of participants had taken at least one herbal or dietary supplement within a week of taking the survey. The study authors noted that when vitamins and minerals were removed from analysis, the percentage of users dropped to 50.2%. There was no statistically significant difference in use patterns between male and female college students, and there was no difference in use by age.²² A study performed by Johnson and Blanchard²³ sought to identify alternative medicine and herbal supplement use among college students. The authors surveyed 506 students, and found that 79% of the sample had used at least one herbal supplement in the year prior to the survey. The most commonly used herbal products used were green tea (41%), ginseng (29%), chamomile (26%), ginger (25%), and Echinacea (22%). Using regression, the authors found that gender was not a predictor of herbal supplement use ($p = .22$).²³

Another study, which used 91 Canadian non-athlete college students as a control group to Canadian university athletes, found that 96.7% of controls were using one or more dietary supplements a once a month.²⁴ After the authors excluded caffeine (due to many participants not listing the use of such for ergogenic benefits) the percentage of controls who were using supplements was 78.6%. Both numbers were lower than the usage rates of varsity athletes (with caffeine--98.6%; without-- 94.3%). The authors noted that there were no significant differences in the use of supplements between males and females in the control group. Of note, this study did include products such as sports drinks and carbohydrate gels, dissimilar to other studies that did not include such products as dietary supplements.²⁵ Health professionals and the Internet were the most frequent sources of dietary supplement information for the control group.²⁴ The results of

these studies^{22, 24} revealed that there was no statistically significant difference in herbal and/or dietary supplement use by gender in some surveyed college populations.

A thesis study conducted by Webb²⁶ sought to identify dietary supplement use and beliefs related to college major, physical activity frequency, and body mass index (BMI). The author used 306 students enrolled in an introductory nutrition course as the study population and administered the survey prior to a class discussion regarding dietary supplements. The instrument contained two sections. The first section asked about the use of specific supplements, frequency of use, and self-reported height and weight (to calculate BMI). The second section focused on health beliefs of supplement use and contained 22 belief statements on a five-point Likert-type scale which was used to calculate a total supplement health belief score (higher score indicated a stronger belief in dietary supplements). The author separated dietary supplements into three categories: vitamin and minerals, herbal products and ergogenic aids.²⁶

The study found that 74.5% of respondents reported using at least one vitamin or mineral supplement within 12 months prior to the survey. Multivitamins, at nearly 55% of total respondents, was the most commonly used supplement type. Just over 50% of participants reported using an herbal supplement (e.g. Garlic, Cranberry, Ginseng, Echinacea, Ginkgo) while 12.7% reported the use of an ergogenic aid (e.g. creatine, chromium, protein, pre-workout product). The use of ergogenic aids varied the most based on major, physical activity and also weight status. Specifically, the use of ergogenic aids was more common in non-health majors ($p < 0.01$), those with a BMI of ≥ 25 ($p < 0.001$), as well as in those who reported daily physical activity ($p < .001$). Dietary supplement belief scores varied by exercise frequency and also by BMI. Participants who

exercised daily had higher dietary belief scores compared to those with less frequent physical activity patterns ($p<0.05$). Additionally, those with a BMI of ≥ 25 had higher belief scores compared to normal or underweight counterparts ($p<0.05$).

The author also wanted to determine whether or not there were significant differences in supplement use between genders. Females were more likely to have used an herbal supplement, used a multivitamin on a monthly basis and also to have had a lower health belief score compared to male participants. Males were more likely to have consumed ergogenic aids (both in general and on a daily basis), taken multivitamins on a daily basis and to have had higher health belief scores. The results of this study indicated that the use of dietary supplements was very common in the college population and that the use of ergogenic aids varied based on type of major, BMI and physical activity. The study also demonstrated that characteristics such as exercise patterns and BMI influenced students' perceptions of dietary supplement efficacy.²⁶

Most recently, Lieberman et al²⁵ surveyed 1248 college students at five different universities regarding dietary supplement use. In a six-month period prior to taking the survey, the authors found that 66% of college students used dietary supplements at least once a week, 41% used multiple supplements per week while 12% took more than five different supplements per week. Of note, the authors did not include sports drinks, sports bars or gels, and/or meal replacements in their analysis, which is different from the survey methodology of Kristiansen et al²⁴ who did include such products for analysis. Their study found that 42% of students used multivitamins, 29% used individual vitamins, while 18% used vitamin C, 17% used a protein supplement or amino acid, 13% used supplemental calcium and 9% used an herbal supplement.

Lieberman et al. (2014) noted that 73% of surveyed users stated that their reason for use was for promotion of general health. Twenty-nine percent reported use for energy provision, 20% for muscle strength and 19% used supplements to enhance performance. Additionally, 19.5% of students spent \$30 or more a month on dietary supplements. The average amount of money spent per month on supplements higher in males (\$24) compared to females (\$12). The most popular source of dietary supplement information for males was the Internet; the second most popular source was friends. For females, the most common source of supplement information was family, also followed by friends.²⁵

Other literature pertaining to supplement use in the collegiate population has focused solely on nonvitamin, nonmineral (NVNM) dietary supplements. For instance, a study performed by Gardiner et al²⁷ surveyed 6,666 young adults (aged 18-30) and found that 17% had used an herbal or dietary supplement within 12 months of the study. The most commonly used dietary supplements were Echinacea (45%), ginseng (34%), ginkgo biloba (22%) and garlic (15%). Of those participating, 40% reported “some college” as their education level while 19% listed “college graduate.” In those listing “some college,” 19% reported NVNM use while 25% of “college graduates” reported NVNM use. Both of these values are higher than the overall findings that 17% of 18-30 year old participants used NVNM supplements. Additionally, prevalence of supplement use was higher in the college groups compared to those who reported their education level as “< high school” and those who listed their education level as “high school grad.”²⁷ These results suggested that NVNM use was more common in those with some college experience or a degree compared to those without either.

Focusing on college students, Perkin et al.²⁸ sampled 1,000 college students at an urban, mid-size university. Just over 80% of those sampled were undergraduate students. The study found that 26.3% of those surveyed reported using NVNM dietary supplements at the time of the study. Furthermore, 16% of participants reported past use of NVNM. Twenty nine percent of users were taking just one supplement at the time of the study. The average number of supplements consumed by users was 2.7. Among the 26.3% (n=263) of those who reported using supplements, ginseng (29.7%), echinacea (27.8%), protein powders/amino acids (22.8%), ginkgo biloba (21.3%), and creatine (17.9%) were the most commonly reported dietary supplements. Similar to the more recent study by Lieberman et al.,²⁵ friends and family were commonly listed as the chief source of supplement information (51.7%).²⁸

While the authors noted no difference in supplement use versus non-use by gender, women were more likely to use supplements for weight loss ($p < .001$). Men were more likely to use supplements to build muscle ($p < .001$).²⁸ These results are similar to the findings of Jackson et al.²⁰ Looking at all users, the most common reasons for supplement use included energy improvement (61.2%), weight loss (38.0%), fat burning (36.1%), supplementation of an inadequate diet (35.0%), and muscle building (27.8%).²⁸ With just 26.3% of participants reporting supplement use, the results of this study indicate that supplement use amongst college students has increased since the year 2002. However, it should be noted that this study only included NVNM supplements, which means that vitamins and minerals were not included. Such exclusion could decrease the percentage of users, as vitamin and mineral supplements are very commonly used in the college population.^{20,25,26} Additionally, the authors made no

mention of the inclusion of sports drinks or products such as carbohydrate gels. While such products are not technically considered to be dietary supplements,²⁵ some studies do include such products in their dietary supplement investigation and analysis. One study that did include such products²⁴ had a much higher rate of supplement use (96.7%) in the college student population, indicating that not including these products might lower the total percentage of students reporting supplement use.

Another study focusing on the use of NVNM dietary supplements in the college population utilized 272 students' responses to a mailed survey.²⁹ The survey was designed to assess the extent of supplement use and non-use by demographic variables and also to assess perceived health benefits and efficacy of supplements. The authors found that 48.5% of participants had taken a dietary supplement within the 12 months prior to the survey administration. Fifty one percent of females reported use compared to 44.7% of male participants.²⁹ Similar to the findings of Perkin et al,²⁸ the average number of supplements taken per user was 2.3. Furthermore, 42% of users reported taking one supplement, 25% took two supplements and 33% reported taking three or more. The most commonly used herbal products were Echinacea (20.2%), Ginseng (14.3%), St. John's wort (14.0%) and ginkgo biloba (8.5%). The most common non-herbal products (ergogenic aids) were chromium (5.8%) and creatine (4.8%).²⁹ The most commonly used NVNM supplements were similar to the findings of Perkin et al.²⁸

Examining reasons for NVNM supplement use, 54% of supplement users reported taking supplements for promotion of good health, to prevent disease or to enhance immune function. Of those taking supplements for any of the reasons above, 77.5% believed the supplements took were effective. Additionally, 82% of those who took

ergogenic aids (e.g. creatine) believed that the products they took were effective. Overall, 77.8% of users believed that the products that they were taking were effective. The supplements with the greatest perceived effectiveness included kava kava (100%), ephredra containing products (96%), chamomile (89%), goldenseal (87%), echinacea (81%), and ginkgo biloba (79%). When comparing users to non-users, the authors also found that those who used NVNM supplements believed that NVNM were effective in helping to prevent or control certain diseases more so than non-users ($p < .001$). The authors also assessed reasons for not using NVNM supplements, and the most common response provided by non-users was a lack of knowledge.²⁹ The results of this study indicated that college students who used NVNM supplements generally believed that they were effective in helping them to meet their goals.

Looking at the use of NVNM supplements at a Public Turkish University. Ayranci, Son and Son³⁰ sampled 1,871 students and found that 16.5% of were using at least one NVNM dietary supplement at the time of the study. Students most commonly listed “improvement in energy and vitality” (78.6%), “promotion of weight loss” (71.1%) and “enhancement of athletic performance” (64.3%) as their main reasons for use. Lower than the findings of other studies,^{28,29} the average number of supplements taken per user was 1.6. Similar to the findings of Perkin et al²⁸ and Newberry et al,²⁹ the three most frequently reported supplements were Echinacea (38.6%), ginseng (36.4%), and ginkgo biloba (32.8%). Protein powders and/or amino acids were used by 28.9% of users, while fish oil was used by 27.3% of users and creatine was used by 14.6% of users.³⁰

Similar to the methodology of Webb,²⁶ who cited the study design of Ayranci and associates³⁰ in designing the thesis study, Ayranci and associates³⁰ also measured

health belief scores using the five-point Likert scales. On this scale, a higher value indicated a stronger belief in effectiveness of NVNM supplements for a particular item (e.g. improving energy and vitality, recovery from fatigue etc.). Looking at comparisons by gender, women agreed more strongly about NVNM effectiveness with health maintenance, stress reduction and sleep enhancement compared to men. Men agreed more strongly about the effects of NVNM on sexual function improvement. The authors found, in general, that users of NVNM supplements had stronger beliefs in their effectiveness compared to non-users. The only instance where non-users had a higher belief score to a question was with the belief statement “burning up fat accumulating in the body.” With this belief statement, non-users had a mean score of 2.9 whereas users had a mean score of 2.8.³⁰ The fact that this study was conducted at a Turkish university may limit the ability to generalize the results to the American college population.

Dietary Supplement Use in Collegiate Athlete Samples

Ambrose et al³⁹ analyzed data regarding the types and brands of dietary supplements that NCAA athletes were inquiring about through the National Center for Drug Free Sport, also known as the Resource Exchange Center. This is a resource for NCAA athletes to submit questions regarding the legality, efficacy and/or safety of dietary supplements and other substances.⁴⁰ The investigators, who used a one-year collection window consisting of nearly 25,000 submissions, found that the most common dietary supplement inquiries were for amino acid/metabolite products, vitamins and minerals, and herbal supplements. One particular dietary supplement marketed as a “pre-workout” stimulant product accounted for the majority of specific dietary supplement inquiries.³⁹ The results of this study showed that college athletes were interested in

dietary supplements and also that some were willing to seek out reputable information to ensure that the products they took, or were thinking about taking, were safe and legal.

Previous research has focused on dietary supplement usage rates, perceptions and other information regarding supplement use in NCAA athletes with varying results. Herbold and associates⁴¹ surveyed 162 female collegiate varsity athletes to assess prevalence of dietary supplement use. The investigators found that 65.4% of surveyed female athletes reported using at least one supplement at least once per month. The most commonly cited supplement was a multivitamin/mineral with iron (35.8% of all athletes), followed by vitamin C (31.5%), calcium (14.2%), Echinacea (13.7%) a multivitamin/mineral without iron (13.5% of athletes), and amino acids/protein (12%). The authors noted that herbal/botanical supplement use was only reported by 17% of surveyed athletes. The most commonly cited sources of supplement information included family (53%), friends (24.6%), physicians (18.7%), coaches (10.5%) and nutritionists (8.2%). Sixty percent of female athletes reported taking a supplement for good health.⁴¹ The results of this study indicated that supplement use was common in collegiate female varsity athletes.

Froiland and colleagues⁴² surveyed 115 male and 88 female NCAA athletes at a Division I university and found that 61% of surveyed athletes were using a supplement at the time of the study. When including past use as well as current use, 89% of surveyed athletes had used or were, at the time of the study, using at least one dietary supplement. Looking at the frequency of supplement use, 23% of those surveyed were taking supplements >5 times per week, 16% reported use two to four times a week, while 22% of surveyed students used supplements less than two times per week. Nearly 73% of

athletes reported use of energy drinks (e.g. Gatorade, Powerade, Red Bull), 61.4% reported consumption of calorie replacement products (e.g. Boost, Slim Fast, PowerBars).⁴²

Creatine was used by 37.2% of student athletes, which was higher than the findings of a 1999 study by LaBotz and Smith⁴³ who found that 28% of surveyed NCAA Division I student-athletes reported creatine use. Protein powder was consumed by 21.7% of athletes. Vitamin use was reported by 67% of those surveyed with multivitamins being used by 47% of athletes. The most popular individual vitamin supplement used was vitamin C (32.4%), followed by vitamin E (15%) and vitamin A (10.1%). The most commonly reported herbal supplements were ginseng (13%) and echinacea (9.7%). Overall, just over one-quarter of students reported herbal supplement use.⁴²

The investigators also broke down supplement use by gender. Males were significantly more likely to use energy products, protein supplements, creatine and weight gaining products (all $P < .05$). Females were more likely to report use of multivitamin supplements ($p < .05$). Of note, male athletes had particularly high rates of protein and creatine consumption compared to female athletes; nearly 35% of males reported creatine use and 40.9% of males reported using a protein supplement. Only 3.4% of females reported taking creatine and 8.4% of females reported taking a protein supplement. The finding that creatine use was common among males but not among females is largely in line with the findings of LaBotz and Smith⁴³ who found that, in a sample of 750 NCAA Division 1 athletes, only 4% of female respondents reported creatine use compared to 48% of male respondents. Male athletes were noted to be

significantly more likely to take supplements for speed or agility enhancement, strength and power or for weight/muscle gain (all $p < .05$). Female athletes were noted to be significantly more likely to take supplements for an inadequate diet or for their overall health (both $p < .05$). The most frequently reported sources of supplement information were family members (32.4%), fellow athletes (31.9%) and a registered dietitian nutritionist (28.5%).⁴² The finding that family was the most common source of supplement information was similar to the findings of Herbold and associates.⁴¹ The results of this study indicated that supplement use was common and also that supplement use may differ by gender in the NCAA athlete population.

Another 2004 study performed by Burns and associates,⁴⁴ surveyed 236 university student athletes to assess supplement use, perceptions of supplement efficacy, overall sources of information, and whether or not registered dietitians were consulted for supplement related information.⁴⁴ The investigators found that 88% of surveyed athletes were using at least one dietary supplement. Fifty-eight percent of respondents reported using at least two dietary supplements. The most commonly used dietary supplement was a vitamin/mineral supplement (73%) followed by calorie replacement supplements (47%) and protein supplements (40.3%).

Burns and associates⁴⁴ noted that perceived efficacy of supplementation was moderate with the highest average score being for 2.9 (using a five-point Likert scale). The most frequently reported sources of information were athletic trainers (39.8%), followed by a strength and conditioning coach (23.7%). Dissimilar to the findings of Froiland et al. (2004), only 14.4% of those surveyed reported a registered dietitian as their primary source of information, despite nearly half of surveyed athletes reporting that

there was a dietitian on staff. The authors concluded that supplement use is common with student athletes and that registered dietitians should market themselves to this population.⁴⁴

Kristiansen et al²⁴ surveyed 247 varsity athletes representing 17 different sports teams and found that supplements were being used by 98.6% of those surveyed. When caffeine was excluded (as the authors noted caffeine was rarely listed as used for performance reasons) 94.3% of varsity athletes reported using at least one supplement once or more a month. The authors used non-varsity athletes as the control group, and noted that supplement use was higher among varsity athletes compared to the control group (excluding caffeine: 94.3% versus 78.6%). Looking at each supplement by gender, carbohydrate supplements (e.g. sports drinks, bars/gels) were used by 91.6% of varsity male athletes, while 81% of varsity female athletes reported use of carbohydrate-based supplements. Fifty one percent of varsity male athletes reported taking a protein supplement compared to 42.7% of female athletes. Just over 9% of male athletes used creatine, whereas none of the surveyed female athletes reported creatine use. Additionally, nearly 52% of male athletes and nearly 63% of female athletes reported the use of vitamin and mineral supplements and 30% of varsity men and nearly 26% of women reported the use of non-vitamin non-mineral supplements (e.g. herbal products).²⁴

Participants were also asked about whether or not they researched supplement information prior to beginning to take a product. Thirty seven percent of male athletes and 32.6% of female athletes indicated they had researched supplement information. Health professionals and the Internet were the most commonly reported sources that athletes used for information. Looking at reasons for use, “providing more energy” was

the most common reason for using carbohydrate supplement in both male and female users. “Enhanced recovery” and “greater muscle strength” were the most commonly reported reasons that male athletes took protein supplements while women most frequently listed “enhanced recovery” and “taste”. In the male athletes taking creatine, “greater muscle strength” was the most common reason and “to meet nutrient needs” was the most common reason for using vitamins/mineral products in both male and female athletes. The authors also noted that “taste” and “counteracting tiredness” were the most frequently reported reasons for caffeine use with coffee and soda accounting for most of the caffeine containing products used. From this, the authors then assumed that caffeine is “rarely used for its ergogenic benefits, but rather for the pleasure and alertness it produces.”²⁴ (p.207)

Focusing solely on vitamin and mineral supplementation at a Midwestern Division I university, Krumbach, Ellis and Driskell⁴⁵ surveyed 411 student-athletes and found that 57% of those surveyed were taking a vitamin or mineral supplement. Breaking the number down by frequency of use, 18% reported using vitamin/mineral supplements ≥ 5 times per week, 21.2% reported use 2-4 times a week while the same percentage (21.2%) reported use once a week. Although deemed statistically insignificant, female athletes (59.3%) had higher rates of use than male athletes (55.3%).⁴⁵ Unique from other studies in student athletes, but similar to Newberry and associates,²⁹ the investigators asked participants who were not using supplements to explain their reasoning for not using. At 35%, non-using female athletes most frequently listed “personal or religious beliefs” followed by “diet adequate” (26%) and “too expensive” (14%). Male athletes who were not using supplements most frequently listed “diet

adequate” (37%), “personal or religious beliefs” (31%) and “too expensive” (30%) as their reasons for non-use. Of note, participants could select as many reasons as applied to their reasoning.⁴⁵

Similar to other studies in the college athlete population,^{24,42} the authors asked users to list why they were using vitamin/mineral supplements. Overall, the two most common reasons for using vitamin/mineral supplements were “recommended by family member or friend” and “improve athletic performance.” By gender, females most commonly listed “recommended by family member or friend” (48%), followed by “prevent disease” (31%) and recommended by a coach or trainer (29%). Male athletes most commonly reported “improve athletic performance” (43%), “build muscle” (36%), followed by “recommended by family member or friend” as reasons for use. While subjects most often listed “self” as their information source, 32.1% reported a nutritionist/dietitian their source of information while 31.1% reported a family member or friend.⁴⁵

The finding that family and friends were common sources of supplement information was similar to the findings of Herbold et al.⁴¹ and Froiland et al.⁴² In terms of significance, males were significantly more likely to list a nutrition professional as a source of information compared to females (36.5 versus 24.1%, $p < .05$). Football players were more likely than other male athletes to list a nutrition professional as a source of supplement information (42.9 versus 30.7%, $p < .05$). These results suggest that males, in particular football players, may be more likely to consult a nutritionist/dietitian for dietary supplement information.⁴⁵

When looking at the types of vitamin/mineral supplements taken by the study population, multivitamins and minerals were the most commonly reported supplements by both males and females with roughly 70% of those reporting supplement use taking a multivitamin/mineral product.⁴⁵ Also similar to the findings of Froiland et al⁴² and Herbold et al,⁴¹ Vitamin C was the second most commonly used vitamin/mineral supplement product. Female athletes were noted to be significantly more likely to take calcium and iron compared to males ($p < .05$) while male athletes were more likely to take vitamin B₁₂ and vitamin A ($p < .05$). The results of this study indicate that vitamin/mineral supplements were used by over half (56.7%) of a Division I student-athlete population, which is a similar number to another study²⁴ but was less than others.^{41,42,44}

More recently, a study published in the *Journal of American College Health* investigated whether or not there was a significant difference between male and female collegiate athletes' use of dietary supplements to modify body appearance.⁴⁶ The authors surveyed 241 female and 210 male collegiate athletes from both varsity and intramural sports clubs. The study found that that 42.4% of surveyed male athletes and 99.1% of female athletes used dietary supplements. This difference was noted to be statistically significant ($p < .001$). The investigators noted that the higher prevalence of dietary supplements among women could be due to the "generic nature of the term dietary supplement."^{46(p.518)} Of interest, the authors also noted that surveyed male athletes reported taking supplements more frequently than women (males: 4.79 days/week, women: 3.9 days/week). It was noted that this finding might have implied that athletes

had "...erratic use of various multivitamin/minerals intended for every day consumption or that consumption of sports bars and drinks may be included in this category..."⁴⁶ (p.518)

Both male (81.5%) and female athletes (81.3%) were likely to report the consumption of protein shakes. The frequency of consumption of protein shakes was reported to be 4.35 days per week for males and 4.24 days per week for females. A significantly higher percentage of females (33.8%) compared to males (9.6%) reported the use of weight loss supplementation ($p < .001$). Women also reported a higher frequency of use with 3.76 days per week compared to males reporting use an average of 2.6 days per week. Products designed to help increase body size, did not significantly differ between males (27.2%) and females (25.5%). The investigators noted that this finding, along with other findings (e.g. no difference in the use of protein supplements by gender), may help to support the notion that male and female collegiate athletes behave similarly.⁴⁶

High rates of supplement use were also seen in a study that surveyed college students through a multi-round questionnaire from various colleges around the country.⁴⁷ The authors were interested in assessing the prevalence of dietary supplement, energy drink, and prescription medication use by general college students and also by college students of various levels of athletic competition (e.g. NCAA, Club and/or Intramural athletes) to enhance athletic performance. Four hundred and sixty-two college students reported that they participated in sports at varying levels of competition. Of those reporting sport participation, 64.1% reported dietary supplement use while 80.1% reported energy drink consumption. By gender, 89% of male athletes reported supplement use while 81% females reported supplement use. Focusing specifically on

athletes at the intercollegiate level, use of performance enhancing substances (energy drinks, supplements and/or prescription medications) was found in 89.4% of surveyed intercollegiate athletes. By type of product used to enhance athletic performance in the intercollegiate athlete population, energy drinks were used by 85% of intercollegiate athletes; dietary supplements were used by 68% of intercollegiate athletes while prescription medications were used by roughly 51% of surveyed intercollegiate athletes. The results of this study indicated that the use of performance enhancing products was common among both male and female intercollegiate athletes.⁴⁷

Dietary Supplement Use In Military Samples

Young adult military personnel must meet rigorous standards for both physical performance and body composition and thus are theoretical candidates for increased rates of dietary supplement usage.³¹⁻³³ Members of the United States Military have been surveyed regarding supplement use with varying results; however, there is very limited information pertaining to the use of dietary supplements among Army ROTC Candidates. Stasio et al²² did include 21 ROTC cadets in their study regarding over-the-counter medication and/or herbal or dietary supplement use in college students. The authors found that of the twenty-one surveyed, 85.7% of ROTC Cadets reported herbal or dietary supplement use. The percentage of users in the ROTC subgroup (n=21) was higher than the overall usage rate of 70.6% in their entire survey population of college students (n=201).²²

Additionally as reported by Knapik et al,³⁴ in a recent systematic review and meta analysis, a study conducted at the West Point U.S. Military Academy found that 14% of a group of 119 male cadets and 35% of a group of 86 female cadets had used a dietary

supplement within seven days of being surveyed.^{35, 36} Also reported by the same meta analysis³⁴ a study conducted with 50 females enrolled in basic officer training found that 38% reported using a dietary supplement within seven days of being surveyed with multivitamin and mineral supplements being the most commonly reported supplement.³⁷ While research on ROTC cadets is limited, other populations of military personnel provide insight regarding dietary supplement use and trends within the armed services population.

Cassler et al³² set out to assess the use of supplements among 329 active duty Marines (USMC) at Camp Leatherneck, Afghanistan. Overall, 70% of respondents reported supplement use within 30 days of the survey. By gender, 72% of Male Marines and 42% of Female Marines had used a supplement within 30 days of the survey ($p < .001$). Military rank also was also a factor in determining supplement usage. Higher rates of use were seen in those with officer status and also those who were classified as lower ranking ($p = .096$). Of those who were using supplements, 27% of users reported not using supplements prior to deployment ($p < .001$). Seventy-four percent of those who reported taking dietary supplements were taking more than one dietary supplement. The most commonly reported products used were protein (64%), multivitamins (47%) and stimulant products such as energy drinks (42%), and commercially branded stimulant products such as *N.O.-Explode*® (20%) and *Jack3d*™ (18%).³²

The most common reasons for use were strength (54%), job performance (30%), appearance (28%), weight gain (16%), and weight loss (9%). Health promotion only accounted for 3% of reasons for use, dissimilar to a recent study in the college population²⁵ where general health promotion was the most commonly listed reason for

use. Similar to studies in the college population,^{29,30} users had very favorable perceptions regarding the efficacy of the products they were taking. Eighty-one percent of current users noticed an improvement in physical performance as a result of taking dietary supplements. In terms of money spent, 80% of respondents spent less than \$100 per month on dietary supplements. Many Marines used the Internet for supplement information (48%), while 38% listed friends as sources and 10% listed a medical source.³² The results of this study showed that use is common in the Active duty Marine population and also that many Marines believe in the benefits of dietary supplements.

Another study focused supplement use in USMC Recruits.³³ Of the 323 surveys analyzed, 50% of respondents reported some type of dietary supplement use before admittance into the USMC basic training program. Of users, the most commonly reported dietary supplements were protein powders (43%), post workout recovery drinks (36%), vitamin supplements (26%), creatine (26%) nitric oxide (16%) and fat burners (16%).³³ These results are similar to the findings of Cassler et al.³² The authors noted males were significantly more likely to use creatine, nitric oxide, post recovery workout drinks, glutamine and protein powder (all $p < .01$) compared to female recruits.³³ The results of this study indicated that use was common in USMC Recruits and also that ergogenic aids (e.g. creatine, protein powder) were more common in male recruits than in female recruits.

The U.S. Army Research Institute of Environmental Medicine administered the *Dietary Supplement and Caffeine Intake Survey of US Army Active-Duty Personnel* to discover the prevalence, frequency and reasons for supplement use among 990 Active Duty Army Soldiers.³⁸ Overall, the authors found that 53% Army soldiers had used a

dietary supplement (excluding sports drinks, bars, gels and/or meal replacements) \geq one time/week in the six months prior to the survey. The prevalence of dietary supplement use was highest in the officer subgroup (69%) versus Enlisted E1-4 (43%), Enlisted E5-9 (59.0%), and warrant officer (57.4%) groups; this difference was deemed statistically significant ($p < .01$). By gender, 52.6% of males had taken a supplement while 57.3% of females had taken a supplement; however, this difference was not deemed statistically significant. The authors did note that men were twice as likely (25% versus 12%) to spend $>$ \$50 a month on dietary supplements compared to women ($P < .01$). Overall, the average amount of money spent was \$38 per month, while a total of 23% of soldiers spent greater than \$50 per month on supplement products.³⁸

Looking at the percentage of users who were consuming multiple dietary supplements, 31.1% of respondents reported taking 1-2 different supplements, 9.9% reported 3-4 supplements per week while 12.2% reported taking \geq 5 supplements.³⁸ The authors noted that higher-ranking soldiers (e.g. officers) reported taking fewer different dietary supplements per week compared to enlisted soldiers. The most commonly used supplements were multivitamins/multiminerals (37.5%) followed by protein/amino acids (18.7%). Nearly 12% of respondents reported using a dietary supplement categorized as “other.” Examples of other supplements included caffeine tablets, fish oil and/or melatonin.³⁸ The finding that multivitamins/multiminerals and protein/amino acids were among the most commonly used supplements were similar to the findings in other studies within in the military population.^{32,33}

Lieberman et al³⁸ also asked participants to list reasons for supplement use. The most common reason for use was for general health promotion (64.1%), followed by

energy provision (31.1%), greater muscle strength (24.9%) and performance enhancement (16.7%). Of note, there were differences in the reasons for use of individual supplements. For instance, 76% of multivitamin/mineral users reported use for health promotion while 59% of protein/amino acid users reported use for greater muscle strength.³⁸ The finding that health promotion was the most frequently reported reason for supplement use (64% of users) is dissimilar to the findings of Cassler et al³² who sampled Active Duty Marine Soldiers and found that only 3% reported health promotion as their reason for use. The findings of this study indicated that male soldiers were more likely to spend greater amounts of money on supplements, and also that the prevalence of supplement use was higher among officers compared to enlisted soldiers.

A separate study that used the same data set as that of Lieberman et al³⁸ aimed to assess a potential relationship between supplement use and weight modification goals in Active Duty Army Soldiers. The survey found that 70.3% of respondents (N=990) had consumed at least one nutritional supplement within the previous six months before the survey.³¹ This number is different from the overall use reported by Lieberman et al³⁸ because Austin et al³¹ included sports drinks, bars, gels and meal replacement beverages that Lieberman et al³⁸ did not include. Such inclusion increased the overall prevalence of supplement use among this data set (70.3% versus 53%). In discussing their results, Austin and associates³¹ pointed out that sports nutrition supplements (e.g. sports drinks, bars, gels, meal replacement products) and products designed for health promotion (e.g. vitamins/minerals) were significantly more likely to be consumed by officers compared to enlisted soldiers. The authors also found that the use of nutritional supplements was not significantly related to respondents' desire to lose, maintain or gain weight. It was

concluded that supplements were used in the active duty military population regardless of weight management goal.³¹

Most recently, Knapik and colleagues³⁴ performed a systematic review and meta-analysis regarding the prevalence of dietary supplement use by military personnel from all branches of the United States Armed Forces (i.e. Army, Navy, Air Force, and Marine Corps, respectively). The initial search yielded 2,930 potential publications from which to draw information. After analyzing the publications for review criteria, 33 investigations from 38 publications were included. The authors noted that there was a variance in the reporting timeframe between the selected studies. Thirteen studies asked for supplement use ≥ 1 time per week, 10 studies analyzed current use but did not specify the frequency of use, three studies reported use within seven days, one study asked for use within a month, two studies asked about use within the last three months, one study asked for the last six months, three studies asked for the past year, while one study focused on two years prior to survey administration, two studies asked for lifetime use, two others asked for daily use and one study did not state the time frame.³⁴

Looking at the results, Knapik et al³⁴ reported that among men in the four military services, use of any type of supplement ranged from 53% to 61% of surveyed populations. Overall use was higher in women, with use of any type of supplement ranging from 66% to 76%. Supplement use was deemed more prevalent in elite Army and Navy groups (i.e. special forces, Ranger units, SEALs) with use ranging from 56% to 90% of those surveyed. The most commonly reported supplement was multivitamin/multimineral supplements (MVM). MVM use ranged from 24% to 47% for men. MVM use in military women ranged from 28% to 63%. The authors noted that

MVM use was less common in both Army men and women compared to their counterparts in other branches of the military and also that reported MVM use in elite military groups was similar to that of Army men and women (26%-64%).

In discussing the results of the systematic review and meta-analysis, the authors discussed that the available data indicated that the use of supplements was high among members of the military with use even higher in elite groups. The data also indicated that overall supplement use was generally higher in female services members compared to their male counterparts in each of the services. Similar to MVM supplements, overall supplement use was observed to be lower in both Army men and women compared to counterparts in other branches. The authors also noted that male and female officers in training tended to have a lower prevalence of supplement use relative to other military groups. The authors theorized that this could be due to the fact that officers in training eat in military dining facilities and also have busy training schedules.³⁴

In terms of specific supplement types, the prevalence of herbal supplement use was seen to be small (most studies <5%). The consumption of sports drinks was seen to be more common with a range of 22-39% of military personnel reporting use of such products. In the elite military population consumption of sports drinks was even more common, albeit with a broader range, with 19%-71% of elite military members reporting use of such products. Creatine use was found to be common in both elite service members (20%) and also Army men (14%). Use of protein/amino acid supplements was highest in elite military groups (20%) and was observed in roughly 13% in the general male army population. The authors also briefly analyzed reasons for use and found that “general health” was the most common reason for use in this population with

performance enhancement being common as well. Summarizing the significant findings of this meta analysis: Army personnel tended to use supplements less than other branches, use of supplements and MVM supplements was generally higher in women than in men, the use of herbal supplements was not common in the military population, and also the elite military population tended to have higher reported rates of supplement use compared to other service populations.³⁴

Dietary Supplement Use and Lifestyle Behaviors in Adult Samples

Bailey and associates⁴⁸ analyzed the 2007-2010 NHANES survey looking for lifestyle patterns and motivations associated with dietary supplement use. The NHANES 2007-2010 survey captured data from 11,956 adults aged 20 years and older. Supplement use was most common in those who had body mass index (BMI) values within a normal range (18.5-24.9), with 52.5% of those within a normal BMI range reporting supplement use. Comparatively, supplement use was reported in 49.1% of those with an overweight BMI (25.0-29.9), 44.1% of those with a BMI of < 18.5 (underweight) and 45.9% of those with a BMI of ≥30 (obese). Additionally, supplement use was seen to be most common in participants who were former smokers (59.2%) followed by those who had never smoked (51.2%). Only 30.6% of those who reported themselves as current daily smokers reported supplement use, indicating that adults who smoke are less likely than non-or former smokers to use dietary supplements.⁴⁸

Supplement use was also seen to be more common in those who exercised more. Nearly 43% of those with self reported “low” exercise levels reported supplement use, and 53.7% of those reporting “moderate” exercise reported supplement use. Both of these values were less than the supplement usage rate of those reporting “high” exercise levels,

which was 56.3%. Looking at alcohol consumption, those who consumed 0-1 drinks per day were more likely to report supplement use than those who consumed 2 or ≥ 3 drinks per day. Those who rated their health as “excellent or very good” were also more likely to use supplements compared to those who rated their health as “good” or “fair or poor.” From the data presented above, the investigators concluded that the use of supplements was associated with a lower BMI, more moderate alcohol use, heightened physical activity levels and non-smoking status.⁴⁸ This use of recent NHANES data shows that many Americans use dietary supplements as part of an overall healthy lifestyle.

Similar to the objectives of Bailey and associates,⁴⁸ another group of researchers analyzed data from the 1993-1996 *Multiethnic Cohort Study* conducted in Hawaii and California.⁹ The researchers found that dietary supplement use was most common in those with overall healthy lifestyles. The investigators reported that “...engaging in regular physical activity was positively associated with dietary supplement use” and also that “obese persons and current smokers were less likely to report such use...”^{9(p.892)} In addition, the researchers looked at dietary variables and any possible association with dietary supplement use, which was performed by utilizing food frequency questionnaires (FFQ) and 24-hour recalls. It was found that “persons who consumed a high fat or low fiber or fruit diet were less likely to use supplements.”^{9(p.892)} These results indicate that adult supplement users generally lead healthier lifestyles compared to non-users.

Other examples of studies that have found supplement users to have more nutritionally sound diets than non users include the findings of Bailey and colleagues who performed two separate studies.^{49,50} The first study⁴⁹ focused on mineral intake, while the second study⁵⁰ focused on vitamin intake. All data was taken from 8860 adults

who participated in NHANES 2003-2006. The authors, in their first study, found that male supplement users generally had higher food intakes of magnesium, copper, potassium and selenium compared to non-users. Female supplement users were found to have higher intakes of every mineral except for selenium from food sources compared to non-users.⁴⁹ The second study, focusing on vitamin intake from food sources, found that male supplement users had higher mean intakes of Vitamins A, E and K from food sources. Female supplement users were found to have higher mean intakes of folate, vitamin A, C, D and E from food sources.⁵⁰ The results of these studies suggest that the diets of supplement users are more nutritionally complete compared to non-using counterparts. The authors also point out that the use of supplements could potentially contribute to the risk of excessive intakes of certain vitamins and minerals, due to high levels of these vitamins and minerals already present in a nutritionally balanced diet.^{49,50}

Looking at weight loss supplements and their potential relation to lifestyle variables, Blanck and associates⁵¹ found that 15.2% of adults over the age of 18 had used a weight loss supplement within a year of the survey. Analysis of the survey responses found that the odds of using of any commercial non-prescription weight loss supplement increased as participants' BMI increased. The data indicated that 16.3% of those with an obese BMI, 11.7% of those with an overweight BMI and 9.0% of those who had a normal BMI used at least one non-prescription weight loss supplement. A higher percentage of weight loss supplement users (51.7%) reported both eating less energy and using physical activity to help facilitate weight loss compared to non-users (43.4%). The investigators also found that a higher percentage of weight loss supplement users (36.4%) engaged in eating less total calories also met physical activity recommendations for overall health

compared to non-users (29.6%).⁵¹ These findings indicate that many weight loss supplement users may adopt other healthy lifestyle behaviors to help achieve their weight loss goals and to become healthier overall.

In a review article focusing on lifestyle trends associated with supplement use in the United States entitled “Health habits and other characteristics of dietary supplement users: A review,” Dickinson and MacKay¹⁰ pointed out that “obese people are less likely to be supplement users...one healthy habit that appears to be adopted by supplement users is to make more of an effort to maintain a normal body weight, or at least to avoid obesity...”^{10(p.5)} To reach this conclusion about obesity and supplement use, Dickinson and MacKay (2014) utilized data from NHANES 2003-2006⁴ and NHANES 1999-2000² as well as the *multiethnic cohort study* performed by Foote et al. (2003). Also pointed out by Dickinson and MacKay (2014) was the finding that “people who exercise more are more likely to use supplements”^{10(p.5)} and also that “users of dietary supplements tend to be people who have never smoked or who have given up smoking.”^{10 (pg.5-6)} These conclusions were cited by using NHANES 1999-2000 data from Radimer et al² and also the results of the *Multiethnic Cohort Study* performed by Foote et al.⁹

Dickinson and McKay¹⁰ also focused on other aspects of healthy living in their review such as diet quality and alcohol consumption. To discuss diet quality, the authors referenced a study published in 2007 in the *Journal of the American Dietetic Association* that focused on older adults (aged ≥ 50) and the differences in dietary attitudes between users and non-users.⁵² Within this referenced article, Sebastian and colleagues⁵² noted, “...the personal importance of consuming a diet consistent with the Dietary Guidelines recommendations was a significant predictor of supplement use...”^{52 (p.1328)} Dickinson

and MacKay¹⁰ also cited the aforementioned diet quality findings of Foote et al,⁹ whose study found that supplement users were more likely to have higher food intakes of fiber and fruit and lower dietary intakes of fat.

To discuss alcohol consumption in relation to supplement use, Dickinson and MacKay¹⁰ used NHANES 1971-1974 data⁵³ and NHANES 1999-2000 data² to discuss the relationship between wine and distilled spirit consumption and dietary supplement use. NHANES 1971-1974 data⁵³ found that wine was positively associated with dietary supplement use while NHANES 1999-2000 data² found that supplement use was highest in those who consumed wine or spirits more than four times a month compared to those who consumed these types of alcohol less frequently or not at all. There was no significant relationship between beer consumption and supplement use.^{2,10} Dickinson and MacKay¹⁰ suggested, similar to the conclusions of Block et al⁵³ that the relationship between supplement use and wine and/or spirit consumption was likely related to socioeconomic status and not binge drinking behavior. These collective results generally indicate that American adult dietary supplement users generally have healthy overall lifestyles with complete diets, adequate physical activity, healthy BMIs and no tobacco consumption.

The observed trend of supplement users also having overall healthier lifestyles may not be isolated to the United States, as European studies have shown. A Spanish study conducted by Rovira et al⁵⁴ measured food consumption over a 12-month period by using an extensive food frequency questionnaire that asked participants to indicate their frequency of consumption of 165 different food items. Participants were also asked to record the name, type and frequency of use of any dietary supplements consumed. The

authors found that those who consumed supplements were more likely to follow a healthier diet compared to non-users. However, the authors noted that there were no significant differences in other lifestyle behaviors such as physical activity, smoking habits or alcohol consumption. However, other European studies have found associations between supplement use and lifestyle behaviors such as physical activity, smoking habits and/or alcohol consumption.

For instance, a 2013 study published in the *British Journal of Nutrition* compared daily food intakes of 24191 supplement users and 31378 non-using French adults using 24-hour dietary recalls.⁵⁵ The investigators found that “overall, dietary supplement users had a healthier diet than non-users—they ate more vegetables fruit, soups/broth, whole grain foods, pulses, fish/seafood, breakfast cereals...and drank more unsweetened drinks...they also ate less potatoes, dairy products...processed meat, cakes/biscuits/pastries, snacks/pizzas and drank less alcoholic beverages...”^{55(p.1483)}

Another French study, performed by Touvier and associates,⁵⁶ found that supplement use was positively associated with fruit and vegetable consumption and negatively associated with the consumption of processed meats/starchy foods and also alcohol/meat products in a group of 64,252 French women.

Also focusing on the female population, a 1998 study used data from 13,822 women who participated in the *United Kingdom Women’s Cohort Study*.⁵⁷ The study authors used a food frequency questionnaire to measure dietary intake for comparison between supplement users and non-users. Also, the authors administered a survey that measured diet category by eating habits (e.g. meat eating, vegetarian, vegan or fish only), measured fruit and vegetable intake by servings per day (e.g. < 2 servings per day, 2-4

servings per day), measured smoking status by “never having smoked,” “ex,” “occasional,” or “regular smoker,” alcohol activity by units per week and physical activity by self reported frequency of activity that cause sweating or an increased heart rate. The authors hypothesized that supplement users would have a healthier lifestyle profile than non-users.⁵⁷ Performing macro and micro-nutrient analysis comparisons between users and non-users from the food frequency questionnaire, the authors found that “supplement users are eating at least as nutritious a diet as non-users, before the effects of supplementation are taken into account, and may therefore be unnecessarily consuming supplements to meet a deficiency in nutrients.”⁵⁷ (p. 71)

The investigators also found that the use of dietary supplements was significantly associated with being vegetarian, vegan, fish eating (as opposed to meat eating) and higher levels of fruit and vegetable consumption. Elevated levels of physical activity, lower levels of alcohol intake and being an ex or occasional smoker (compared to being a current smoker) were also factors associated with dietary supplement use.⁵⁷ The authors concluded, “These findings are consistent with our hypothesis, that supplement users are more likely to have a healthier lifestyle.”⁵⁷ (p.71) Kirk, Woodhouse, Conner and the UKWCS Steering Group⁵⁸ had previously referred to findings that supplement users may have overall healthier lifestyles and diets than non-users as the “inverse supplement hypothesis.” In the findings of the current study, “Diet and lifestyle characteristics associated with dietary supplement use in women,” Kirk, Cade, Barrett & Conner also concluded “the findings of this study further support the inverse supplement hypothesis, that those most likely to use dietary supplements are those least likely to need them.”⁵⁷ (p.71)

The “inverse supplement hypothesis”^{57,58} is further supported by the results presented by aforementioned studies that demonstrated that supplement users have healthier overall lifestyle and/or diet behaviors than non-users.^{9,10,48-50,54-56} While these studies measured self reported lifestyle behavior patterns (e.g. self reported physical activity levels, food frequency questionnaires) in relation to self-reported supplement use, another study sought to objectively measure the health and nutritional status of dietary supplement users using laboratory data.

Block and colleagues⁵⁹ obtained supplement use information from an online questionnaire and also performed a physical examination (12-hour fasting blood sample, blood pressure and body weight) on 278 long-term multiple supplement users (≥20 years of use) in a cross sectional study. The long-term multiple supplement user group “consumed a broad array of vitamin/mineral, herbal and condition specific dietary supplements on a daily basis ” (p.9). Examples of supplements used on a daily basis by over 50% of the multiple supplement group included multivitamins and minerals, B-complex vitamins, vitamin C, carotenoids, vitamin E, calcium with vitamin D, Omega 3 fatty acids. Many of the women subjects consumed a probiotic supplement while many men consumed zinc, garlic and soy protein. Subjects in the multiple supplement group consumed an average of 17 different dietary supplements each day.⁵⁹

The investigators also used NHANES 2001-2002 data (as well as NHANES 1988-1994 data) for comparison subjects who either did not consume any dietary supplements (“No Supp users”-- N=602) or subjects who consumed only a multivitamin/multimineral supplement (“Single supp users”; N=176). Blood samples taken from the long-term multiple supplement users were assayed for health and nutrition

related markers including: red blood cell folate, serum vitamin C, alpha tocopherol, carotenoids, retinol, 25-hydroxyvitamin D, ferritin, C-reactive protein, lipids, and homocysteine. It was found that “serum nutrient concentrations generally increased with increasing dietary supplement use...after adjustment...greater degree of dietary supplement use was associated with more favorable concentrations of homocysteine, C-reactive protein, HDL and Triglycerides...”^{59(p.1)} To summarize and conclude their results regarding the health and nutrition status of long-term multiple supplement users, the investigators stated, “they (multiple supplement users) were more likely to have optimal concentrations of chronic disease related biomarkers, and less likely to have suboptimal blood nutrient concentrations, elevated blood pressure and diabetes compared to non-users and multivitamin/multimineral users.”^(p.9) The results of this study indicated that long-term multiple supplement users may have favorable levels of blood markers indicative of health and nutritional status, more so than those who do not use supplements or those who only use a multivitamin/mineral supplement.⁵⁹

Dietary Supplement Use and Lifestyle Behaviors in Adolescents

In addition to the research focusing on adults, some research also pertains to lifestyle behaviors and dietary supplement use in adolescents. A study performed by the American Dietetic Association (now known as the Academy of Nutrition and Dietetics or A.N.D) sought to determine whether or not a relationship existed between dietary and physical activity behaviors and dietary supplement use in a representative multiethnic sample of 6,422 eleventh grade students.⁶⁰

Of note, the authors only used the term dietary supplement in the context of vitamin/mineral supplements and all other types of supplements such as herbals or

ergogenic aids were not included in the survey or subsequent analysis. To measure dietary patterns, the authors used an instrument that measured the previous day's consumption of 22 "marker foods" that were categorized as either healthful (e.g. whole wheat products, fruits and vegetables, low fat dairy) or unhealthful (e.g. red and/or processed meats, dessert type foods, soda). The investigators noted that a composite score on a 0-27 scale was calculated from the instrument to determine the students' overall diet quality.⁶⁰

Physical activity was measured by inquiring about the number of days during the previous seven days for vigorous activity (cardiovascular and/or muscle strengthening), number of team sports participated in, number of days an average week the student participated in physical education (P.E.) courses and also the number of hours usually spent watching television/movies or playing video games. Body mass index was also measured using standard categorization, as previously defined. The authors found that dietary vitamin use was reported by 23.6% of sampled students. By dietary patterns, the authors noted that for all ethnic groups other than African Americans, dietary supplement users "had a two to threefold greater likelihood of being in the highest rather than the lowest quartile of the healthful food marker foods composite score."^{60(p.388)}

Regular breakfast consumption was positively associated with supplement use in the adolescent population (OR 1.91, 95% CI [1.11 to 3.46]). Breakfast consumption has been shown to be of great benefit for both physical and mental health in the adolescent population.⁶¹ Additionally, higher consumption of low-fat foods was related to the use of supplements in all sex and/or racial ethnic groups besides African Americans (OR [lowest] 2.40, 95% CI [1.24 to 4.63] for boys; OR [highest] 3.59, 95% CI [1.11 to 11.6]

for Hispanics). By physical activity patterns, in the overall sample (with all sex and racial/ethnic groups), use of supplements was associated with higher participation in muscle strengthening activities (OR [lowest] 1.76, 95% CI 1.27 to 2.43 for Hispanics; OR [highest] 3.32, 95% CI 2.18 to 5.06 for whites/others).⁶⁰

Investigators also found that the surveyed 11th grade boys showed positive associations between supplement use and all of the indicators of physical activity (intensity training, muscle strengthening, sports teams and PE classes), whereas girls had more mixed patterns. The authors did not find an association between supplement use and BMI. The authors discussed results by noting, “with the exception of African Americans, dietary supplement use was associated with higher composite scores of overall diet quality and regular breakfast and low fat foods consumption.”^{60(p.389)} Also discussed was the finding that muscle strengthening activities were associated with supplement use in all groups and also that “...the overall association between supplement use and vigorous intensity physical activity is consistent with findings from earlier studies...sports team participation within and outside schools was associated with a greater likelihood of vitamin supplement use...”^{60(p.391)} The results of this study indicated that, with some exceptions by gender and race/ethnicity, vitamin/mineral supplement use was generally associated with more healthful lifestyle behaviors (e.g. healthful dietary patterns, involvement in sports, overall physical activity) compared to 11th grade adolescents who did not use vitamin/mineral supplements.

A prior study performed by Reaves and associates⁶² surveyed 12th graders (N=2761) to assess multivitamin use and lifestyle behaviors in the adolescent population. To assess lifestyle behaviors, students were asked to fill out a survey regarding

multivitamin use, hours of television watched, physical activity frequency and smoking. Students were also asked to fill out a food frequency questionnaire, which the researchers used to compile a food index score. Twenty five percent of respondents were multivitamin users. Looking at lifestyle behaviors of supplement users versus non-users, 55% of supplement users were classified as active compared to 49% of non-users being classified as active ($p=.006$). Twenty nine percent of supplement users reported smoking, while 33% of non-users reported smoking ($p=.04$). Non-users were also more likely to be overweight (37%) compared to users (31%) ($p=.004$). Fifty nine percent of supplement users watched an hour or more of television per day compared with 69% of non-users ($p<.001$). The authors noted that there were no significant differences observed for other lifestyle variables such as alcohol use, P.E. class participation or video game playing.⁶²

Using regression analysis for lifestyle behaviors, it was found that supplement users were more likely to be physically active (OR: 1.30; 95% CI: 1.09, 1.55), participate in team (OR 1.42; 95% CI: 1.10, 1.59) or organized (OR 1.32; 95% CI 1.10, 1.59) sports. Also, supplement users were less likely to watch more than an hour of television daily compared to non-users (OR: 0.66; 95% CI: 0.55, 0.77). Focusing on food and nutrients, supplement users consumed more daily energy ($P=.03$), fiber and more energy from carbohydrates (.009) and protein ($P<.001$) compared to non-users. Similar to the findings of George et al,⁶⁰ users consumed less total and saturated fat ($p\leq.001$) than non-users. The authors also found that fruit ($p<.001$) and vegetable ($p=.003$) intake was higher in supplement users compared to non-users. Supplement users also reported consuming a greater number of dessert servings per day compared to non-users ($P=.04$), but consumed fewer servings of fried food ($P<.001$) and carbonated soft drinks ($P<.001$).⁶²

Focusing on the food index scores, as compiled by the food frequency questionnaires, supplement users had a higher mean overall score of 16.9 compared to a mean of 15.7 for non-users. This difference was deemed statistically significant ($P < .001$). The investigators concluded that, “compared with nonusers, supplement users consumed more healthful diets, watched less television, were more physically active and had a more healthful weight status.”^{62 (p.2022)} The results of this study are similar to that of George et al⁶⁰ and indicate that older adolescent multivitamin supplement users have more healthful lifestyle behaviors compared to non-using counterparts.

Similar to the previously stated findings, Stang et al⁶³ found, through the use of data from the 1994 CSFII (Continuing Survey of Food Intakes of Individuals) survey, that adolescents who reported using reported using vitamin/mineral supplements had higher average dietary intakes of most micronutrients, and also had lower intakes of total and saturated fats. The authors, in their results discussion, stated, “adolescents who used supplements on a daily basis appeared to have more adequate diets than did less frequent users and nonusers.”^(p.908) The authors concluded, “it appears that those adolescents who may have the greatest need for obtaining additional micronutrients by taking supplements are less likely to do so than adolescents with more adequate nutrient intakes.”^{63 (p.908)} The results of this study, in addition to the findings of George et al⁶⁰ and Reaves et al⁶² indicate that older adolescents using vitamin and mineral supplements may be the least likely to need them, due to more adequate diets and overall healthier lifestyles compared to non-using counterparts. These findings are similar to the aforementioned “inverse supplement hypothesis” proposed by Kirk et al which states “those most likely to use dietary supplements are those least likely to need them.”^{57,58 (p.71)}

Dietary Supplement Use and Lifestyle Behaviors in Young Adults

While the existing literature supports a positive relationship between healthful lifestyle behaviors and supplement use in adults and adolescents, this relationship becomes less clear in the young adult population. An early study by Schulz⁶⁴ examined self-reported supplement use and frequency of vigorous activity by 333 college students. Schulz⁶⁴ classified subjects as “sedentary” (activity less than twice per week, N= 116), “exercisers” (activity 2-3 times per week, N=90) or “athletes” (activity \geq 4 times per week, N=127) and found no significant relationship between exercise level and supplement use. However, the study author did find a difference in perceptions of efficacy between active and sedentary individuals. It was found that 76% of those classified as exercisers and 63% of participants classified as athletes believed that the supplements that they were taking were effective. This was compared to only 38% of sedentary users believing the products they took were effective.⁶⁴ The results of this study suggested that physical activity levels may influence belief in the efficacy of supplements.

Gardiner and associates²⁷ analyzed data from the *Alternative Health Supplement to the 2002 National Health Interview Survey (NHIS)* to attempt to identify any association between dietary supplement use and lifestyle/behavior factors amongst the general young adult population (defined as 18-30 years of age). The investigators, in describing their reasoning for conducting such an analysis, proclaimed, “...very little is known about the pattern of (dietary supplement) use among college age and young adults. Young adults are known to engage in high risk behaviors such as alcohol and tobacco

use...little is known about the correlation between high risk dietary supplements (stimulants and depressants) and other young adult's behavior."²⁷ (p.39)

The authors excluded the use of vitamin/mineral supplements. Instead, the authors used data from a list of 35 NVNM supplements, which featured 29 herbal supplements (e.g. Echinacea, ginseng) as well as six non-herbal supplements (e.g. fish oils). Also included in the analysis were questions pertaining to tobacco and alcohol use as well as physical activity patterns. Using data from 6,666 respondents, the investigators found that 17% reported the use of a NVNM supplement within 12 months of taking the survey. The study found that dietary supplement use was positively correlated with high-risk behaviors. Rates of supplement use were highest among former smokers (24%), second highest in current smokers (21%) and was least common in non-smokers (15%). Looking at alcohol consumption, supplement use was highest in those classified as moderate/heavy drinkers (24%) compared to non-drinkers (9%). Supplement use was also highest in those reporting high physical activity (23%) compared to only 9% in those reporting low levels of physical activity reporting supplement use.²⁷

Using regression analysis, the authors found that the factors associated with supplement use included current smoking (OR: 1.41, 95% CI: [1.16-1.72]), former smoking (OR: 1.50; 95% CI: [1.15-1.95]), moderate/heavy alcohol use (OR: 2.02; 95% CI: [1.53-2.65]) and high levels of reported physical activity (OR: 2.45; 95% CI: [1.98-3.03]). The authors concluded by saying "(NVNM supplement use)...is more common among those who smoke, drink alcohol and exercise intensively..."^(p.45) The findings of Gardiner et al²⁷ regarding tobacco use and exercise patterns in relation to NVNM supplement use were echoed by the findings of Perkin et al²⁸ who found that NVNM

dietary supplement use was significantly associated with current smoking ($p=.02$) and also exercising more than three times per month ($p=.001$) in a sample of 1,000 college students. Regarding the findings of smoking and higher rates of supplement use, Perkin et al. (2002) offered a possible explanation that... “Our finding that current smokers were more likely to be NVNM supplement users was surprising...One explanation for usage among student smokers is that usage could be viewed as offsetting a negative behavior (i.e. smoking)...”²⁸ (p.414)

Another study focusing on NVNM supplement use in college students, Newberry and associates²⁹ did not include tobacco use as an independent variable but did include physical activity and perceived dietary adequacy. The authors found that 54.6% of NVNM users engaged in frequent exercise, while 45.4% of non-users engaged in frequent exercise, and 36% of users reported occasional exercise. While demonstrating that users were more likely to engage in frequent exercise and less likely to engage in occasional exercise than non-users, these differences were not statistically significant at the .05 level. A statistically significant difference was observed between users and non-users beliefs that NVNM supplements were effective in helping to prevent or control certain diseases. Users were more likely than non-users to believe in the efficacy of supplementation for this purpose ($X^2(2)=17.31, p < .001$).²⁹ Additionally, the study authors did not find any statistical difference between perceived dietary adequacies in users versus non-users, with both groups reporting a mean of 3.6 (on a likert 1-5 scale). The observations of the relationship between physical activity and supplement use were similar to those of Schulz⁶⁴ who found no significant difference in supplement use by self-reported exercise frequency.

Research findings regarding NVNM dietary supplement use and lifestyle behaviors are not limited to the American college student population. Ayranci, Son and Son³⁰ sampled 1871 students at a Turkish University. The authors included 73 NVNM supplements on the questionnaire and also asked questions regarding physical activity, sports participation, smoking status, and BMI (through self-reported height and weight). The authors found a positive relationship between physical activity and NVNM supplement use. Nearly 23% of supplement users reported physical activity ≥ 3 times per month, while 14.4% of users reported physical activity fewer than three times per month and 16.5% reported no regular physical activity. The difference in reported levels of physical activity among users was statistically significant at the $< .05$ level ($p=.002$). Also statistically significant was supplement use by participation in sport, with those not participating in sport (17.5%) or former participants (17.6%) being more likely to use NVNM supplements than those currently in sport (10.4%) ($p=.010$).

NVNM use was more common among former smokers (25.9%) and current smokers (19.9%) compared to non-smokers (14.3%). These findings were also deemed statistically significant at the $< .05$ level ($p=.000$). In discussing the results of the tobacco finding, Ayranci and associates³⁰ referenced the aforementioned theory of Perkin et al²⁸ that “usage (of dietary supplements) could be viewed as an offsetting behavior.”^(p.414) Looking at BMI status, the investigators found that supplement use was most common in the extremes of BMI values. Use was reported by 32.3% of those who were underweight (<18.5) while 29.5% of those classified as obese reported use ($\geq 30\text{--}\leq 39.9$) compared to 13.4% normal weight participants reporting use ($\geq 18.5\text{--}\leq 24.9$) and 9.7% of overweight

participants reporting use (≥ 25 - ≤ 29.9). This difference in use by BMI status was also deemed statistically significant at the $< .05$ level ($p=0.000$).³⁰

Also focusing on the college population, Lieberman et al²⁵ assessed supplement use along with selected lifestyle factors associated with use in the college student population. The study authors assessed 1,248 college students at five separate universities. The authors used a supplement list, which included 92 different supplements. Participants could also write in supplements that were not included on the list. Also collected was information pertaining to lifestyle such as aerobic exercise duration, overall fitness, tobacco use, dietary preferences and reasons for exercise. BMI was also calculated using the standard range described above in the study by Araynci et al.³⁰

By BMI, use of any dietary supplement (not including sports drinks, bars or gels) was more common in participants who were either underweight (70.8%) or obese (69.1%) compared to normal weight participants (65.5%) or overweight participants (66.2%). The finding that use was more common in both underweight and obese participants was similar to the findings of Araynci and associates³⁰ However, the differences of supplement use by BMI were not deemed statistically significant in the current study ($p=.840$). By diet description (high protein or low fat), overall use of any dietary supplement was significantly higher ($p<.0001$) in those reporting a high protein diet compared to those who did not report following a high protein diet. Additionally, overall use of any supplement was significantly higher in participants adhering to a low fat diet ($p<.0001$) compared to those not following a low fat diet. Use of any type of dietary supplement was also seen to be highest among those reporting >150 minutes a

week of physical activity. Nearly 72% of those reporting 151-300 minutes a week of physical activity reported supplement use while 66.5% of those reporting >300 minutes a week reported supplement use.

Supplement use was seen in 62.6% of those reporting 31-150 minutes/week and 57.9% of those reporting ≤ 30 minutes per week of physical activity. The difference in use of any supplement by exercise duration per week was deemed statistically significant at the $< .05$ level ($p=.016$). The finding that the prevalence of supplement use increased as exercise frequency and/or duration increased was similar to the findings of other studies in the college population.^{27, 28, 30} Supplement use was also significantly higher among those exercising to “increase muscle mass” (72.8%) versus those who answered “no” to this question (63.5%) ($p=.003$). Additionally, the likelihood of taking five or more supplements per week was higher among those reporting exercising to “increase muscle mass” ($p<.001$).²⁵ These results show that college students interested in gaining muscle weight are prone to supplement use and also that some may take multiple supplements per week to help achieve their goals.

Looking at tobacco consumption, the investigators found that 72.8% of current tobacco users reported using any dietary supplement, compared to 68.7% of former users and 64% of those who reported never using tobacco were taking at least one supplement. While these numbers support findings from other similar studies,^{27, 28, 30} regarding a positive relationship between tobacco consumption and supplement use in the college population, the results were not statistically significant at the $< .05$ level in the current study ($p=.098$).²⁵ Using logistic regression, the authors did note a statistically significant relationship between current tobacco use and the likelihood of taking ≥ 5 supplements per

week (OR: 2.70; 95% [CI: 1.71-4.26]). By percentages, nearly 22% of current tobacco users reporting taking ≥ 5 supplements per week while 14.7% of former users and 9% of those who have never used reported taking such an amount. Also noted was the statistically significant finding that former smokers spent an average of \$25 per month on supplements compared to \$21 per month for current users and \$14 per month for those who have never used tobacco ($p < .001$).²⁵

In discussing their results, Lieberman and associates²⁵ pointed out, “another possible negative consequence of use...is that individuals may incorrectly perceive them as a substitute for other healthy behaviors...taking vitamins and minerals in pill form may cause individuals to consume fewer healthy foods or adopt unhealthy lifestyles...our data demonstrating that students on an extreme diet (high protein) are more likely to consume supplements support this interpretation. That students using tobacco products are more likely than their peers to take five or more supplements a week and spend more money on supplements also supports this hypothesis...”^(p.8) While the above studies focused on university students’ use of supplements by demographic and lifestyle characteristics, there is some research pertaining to such information in the military demographic as well.

Young and Stephens³³ used data collected from 323 USMC (United States Marine Corps.) Recruits to assess dietary supplement use and other characteristics such as self-reported height and weight and tobacco use. The mean age of study participants was 19. Using χ^2 analysis, the investigators found that recruits with a BMI of ≥ 25 were more likely to use some types of supplements such as fat burners and protein powders compared to recruits who were of a normal BMI (≥ 18.5 - ≤ 24.9) ($p < .001$). Additionally,

tobacco use was positively related to the use of certain types of supplements including creatine, nitric oxide products, meal replacement products and fat burners (all $p < .001$). The authors noted that “Overweight, male smokers were the cohort of individuals who were the most likely to use nutritional supplements.”³³ (p.159)

Another study focusing on dietary supplement use and lifestyle behaviors in the military recruits surveyed 499 individuals entering basic training. The authors were interested in identifying whether or not the use of ergogenic aids had any relation to health risk behaviors including, but not limited to, tobacco and alcohol use.⁶⁵ The mean age of study participants was 21 years of age and creatine was the most commonly used ergogenic supplement. The authors found that ergogenic supplement use was associated with several health risk behaviors including drinking alcohol (OR 1.8; 95% CI: [1.1-3.1]), drinking alcohol heavily (OR 2.4; 95% CI: [1.5-3.9]), driving a vehicle after drinking alcohol (OR 2.4; 95% CI: 1.3-4.4), and riding in a vehicle with someone who had been drinking alcohol (OR 2.2; 95% CI: [1.3-3.6]).⁶⁵ There was no statistically significant difference observed between ergogenic users and non-users and usage of tobacco products. The authors concluded by discussing that these findings had previously been found in users of anabolic steroids, and that health professionals should ask young adults about their use of dietary supplements to help identify those at risk.⁶⁵

Switching from military recruits to active study soldiers, Lieberman et al³⁸ administered a supplement survey to 990 active duty US Army Soldiers. The authors found that overall, supplement users had higher BMIs ($p < .01$), were less likely to use tobacco ($p < .01$) and also were more likely to engage in strength training at least once a week ($p < .001$) compared to non-users. Using the same data set, but focusing on

nutritional supplement use and weight modification goals, Austin and colleagues³¹ found that the general use of dietary supplements was not significantly associated with specified weight modification goals (i.e. lose weight, gain weight or maintain weight) in the surveyed population. In discussing their results, the authors also noted the following as some of their statistically significant findings: the use of sports nutrition products (e.g. sports drinks, bars and gels) (OR 1.76; 95% CI: [1.16-2.67]) and also weight gain supplements (OR 4.61; 95% CI [1.25-17.04]) was more common in participants who participated in more than 431 minutes of aerobic exercise per week. Both of these supplements were also more likely to be taken by subjects who participated in strength training (OR 13.5; 95% CI: [2.22-82.5] for weight gain supplements and OR: 2.52; 95% CI: [1.81-3.51] for sports nutrition supplements) compared to those who did not participate in strength training.³⁸

The authors also noted that use of “health” dietary supplements (e.g. multivitamins and minerals) was significantly more likely among those who were not using tobacco (OR 1.58; 95% CI [1.18-2.11]). Additionally, participants who self-reported their health as fair or poor were less likely to use health-oriented dietary supplements than those who reported their health excellent or good (OR .73; 95% CI [.56-.97]). The results of these studies showed that within the U.S. Army military population, the use of supplements might be positively related to physical activity.³⁸ The finding from Austin et al³¹ that those who rated their health as fair or poor were significantly less likely to use “health” supplements also supports the “inverse supplement hypothesis” which states “those most likely to use dietary supplements are those least likely to need them.”^{57,58(p.71)}

Selected findings from above support the notion that potentially high-risk lifestyle behaviors such as tobacco consumption^{25, 27,28,30,33} and moderate to heavy alcohol consumption^{27, 65} are positively related to dietary supplement use in the young adult and military population. Such findings are supported by a theory known as the “licensing effect” which was discussed and used as the basis for two experimental studies in research article entitled “Ironic Effects of Dietary Supplementation: Illusory Invulnerability Created by Taking Dietary Supplements Licenses Health-Risk Behavior.”⁶⁶ The investigators, referencing analysis of data from NHANES 1999-2000,² proclaimed that “use of dietary supplements is increasing, but it does not appear to be correlated with improved public health...” and also that “building on the notion of licensing, or the tendency for positive choices to license subsequent self-indulgent choices, we argue that because dietary supplements are perceived as conferring health advantages, use of such supplements may create an illusory sense of invulnerability that disinhibits unhealthy behaviors...”⁶⁶ (p.1081).

To test their theory, the investigators designed two studies to determine whether or not supplement use would influence the desire for different health behaviors. The first study examined the motivation to exercise or engage in hedonic activities after supplement use, while the second focused on walking for health after supplement use. The first study used 82 subjects who were randomly assigned to a control or vitamin pill (supplement) group. All participants were given a placebo, but only the control group was told it was a placebo (the supplement group was not informed of such). The investigators then had all participants complete a short survey regarding health hazard hedonic activities (e.g. excessive drinking) and also exercise related hedonic activities

(e.g. running, swimming) using a desirability scale. Also included was a short survey regarding perceived invulnerability, which asked participants to agree or disagree with questions such as “nothing can harm me.” At the end of the experiment, all participants were offered a coupon for one of two free lunches: a buffet style meal or a healthful, organic meal.⁶⁶

Analyzing the results of the first study, the authors found that participants who were receiving what they thought was a vitamin pill (supplement group) showed lower levels of desire to engage in exercise activities and also expressed greater levels of desire for hedonic activities compared to control participants. Focusing on the results of the invulnerability survey, participants who thought they were taking a vitamin pill had higher levels of reported invulnerability than control participants did. Also found was that 71% of the supplement group chose the buffet meal compared to 44% of those in the control group. The authors summarized the results of experiment 1 by saying “participants who took what they thought was a multivitamin demonstrated more desire for hedonic activities, less desire for exercise and stronger preferences for a buffet meal, compared to participants who took a placebo...the results suggest that the use of dietary supplements may increase perceived invulnerability and thereby license subsequent self indulgent health related behaviors.”⁶⁶ (pp.1083-1084).

The second experiment focused on actual physical activity. The authors noted that the first experiment focused on self reported desire to exercise, rather than actual physical activity, so the authors wanted to design an experiment to assess whether or not supplement use “licenses” supplement users to forgo physical activity. Experiment 2 entitled “walking for health” utilized 68 undergraduate students who were divided into

two random groups. The investigators recorded participants' BMI and number of supplements they were taking at the time of the study. Participants then went through the same manipulation procedure as described in experiment 1 (supplement group versus placebo group). All were asked to complete a similar survey including questions regarding perceived invulnerability. All participants were asked to read a medical report about how important walking is for health, and were then briefed about their task of testing a pedometer device. This task entailed returning the device to another individual at one of two different campus locations; participants had one hour to return the pedometer no matter the location. Location one was 600m away and location two was 1200m away. The investigators also used any additional distance walked as another dependent variable.⁶⁶

The results of experiment 2 showed that students' BMI and/or gender did not significantly predict the choice of meeting place (location one or two). However, participants in the supplement group were more likely than control group subjects to walk to the 600m-point as opposed to the 1200m-point (68% versus 41%). The authors also adjusted for the number of supplements subjects reported taking daily prior to the study, and found that the supplement group engaged in walking less additional distance than the control group, who knew they had received a placebo. Similar to experiment 1, the supplement group also reported higher levels of perceived invulnerability compared to the control group. Akin to the investigators prediction, perceived levels of invulnerability mediated the effects of supplement use on distance walked.⁶⁶

In summarizing the results of experiment 2, the authors stated, "our experiment involving real physical activity demonstrated the licensing effect of dietary supplement

use and the mediating role of perceived invulnerability. Ironically, participants who were given purported dietary supplements walked less than participants who did not, even after being explicitly reminded about the health benefits of walking.”⁶⁶ (p.1084) The results of these experiments indicated that supplement users might be under the impression that dietary supplements enhance invulnerability. This enhanced sense of invulnerability then may serve to inhibit the users perception of the need for engaging in healthy life behaviors (e.g. smaller, more balanced meals and physical activity, cessation of smoking, limiting alcohol consumption). Such findings possibly help to explain why some studies have shown a positive relationship between unhealthy lifestyle behaviors and supplement use in the young adult and military population.

Possible Dangers Associated with Dietary Supplement Use

Timbo and associates⁶⁷ utilized information collected from the *2002 American Health and Diet Survey* to analyze the prevalence of adverse events related to supplement use. Of a total of 2743 conducted interviews, the survey found that 73% of adult participants had used at least one dietary supplement in the last 12 months. Of the 73% reporting use, 4% reported that they had experienced at least one adverse event that they had thought was a result of taking a dietary supplement. The prevalence of adverse reactions was seen to be higher in respondents who were taking multiple supplements (i.e. multivitamins plus a singular vitamin/mineral product plus a botanical/herbal product) compared to those only taking one type of supplement. Those who reported an adverse event were asked to list the dietary supplement(s) and their symptom(s) associated with their reaction.

Multivitamins were reported by 13.3% of those who had experienced an adverse event with symptoms including abdominal pain, blood pressure problems, nausea, vomiting, allergic reactions, dizziness, itching and/or rashes. The second most commonly reported reaction-causing supplement was a commercially sold weight loss/energy supplement. Symptoms associated with this product included abdominal and/or chest pain as well as heart problems. Other noted symptoms thought to have been associated with other supplements (e.g. iron, individual vitamins, herbal products) included anxiety, headaches, diarrhea, difficulty sleeping and cramping/muscle aches.⁶⁷

The authors noted that the most common adverse reaction symptom was heart problems or chest pain, with 12.5% of those who reported an adverse event experiencing such problems.⁶⁷ Those who had experienced an adverse event were also asked to list what they had done after experiencing such an event. Ninety percent of respondents discontinued taking the product(s) in question after experiencing an adverse event. Just fewer than 50% discussed what they had experienced with a physician, 25% reported their event to a health authority, and 12% went to the emergency room while 9% complained to the manufacturer or retailer. Also noted was the fact that 74% of users who reported adverse events also reported taking prescription drugs concurrently with dietary supplements, possibly indicating that concurrent supplement and prescription drug use is a risk factor for experiencing an adverse reaction.⁶⁷ The authors noted that a limitation of the study was that all data was self reported and also that it is difficult to definitively attribute a feeling or adverse effect to a particular ingredient within a multiple ingredient product or to a particular product, especially when multiple supplements are used.⁶⁷

As was noted in the study performed by Timbo and associates,⁶⁷ the most common course of action after experiencing an adverse reaction was to consult with a physician. While a physician is able to provide immediate care and advice to the supplement user in need, the findings of a recent study performed with military physicians found that many physicians do not report adverse events to the FDA⁶⁸—the governing body responsible for maintaining the safety of supplements. The investigators, using two cross sectional questionnaires, found that very few military physicians (18%) reported adverse reactions to the FDA, while nearly 75% of military physicians did not know how or where to report adverse related to supplement ingestion to the FDA.⁶⁸

As referenced by Cellini and associates,⁶⁸ similar results had been observed in civilian physicians in a study performed by Ashar, Rice and Sisson⁶⁹ who found that, prior to taking a module regarding FDA oversight and adverse reaction reporting, physicians had very little knowledge regarding how the supplement industry is regulated or maintained. Physicians also had very little baseline knowledge regarding how to go about reporting a patient's adverse event to the FDA.⁶⁹ The reporting of adverse events by physicians (and also consumers) to the FDA is imperative. As noted by Quinones and associates,⁷⁰ reporting is essential because the overall success of the FDA's regulation on the supplement industry largely depends on post-market reports of adverse reactions from marketers, consumers and also physicians. With a lack of reports, the FDA is not able to investigate dangers associated with supplement products and/or individual ingredients within supplements.⁷⁰

Also noted by Timbo et al,⁶⁷ the second most common avenue for reporting adverse reactions was through speaking with a health authority. While the authors did not

elaborate as to what constituted a “health authority,” one such logical example would be a local poison control center. Reporting to a poison control center, as opposed to reporting directly to the FDA could be problematic information is not always shared between the two organizations.⁷¹ However, there is research pertaining to the prevalence of reports and the types of adverse reactions that supplement users have reported through the poison control route. For instance, Palmer et al⁷² performed a 1-year multi-center observational study regarding adverse reactions to dietary supplements. The investigators analyzed data from 11 different poison control centers that recorded details from 2,332 supplement related phone calls. Of the 2,332 phone calls, 784 calls regarded symptoms that the caller thought were from the ingestion of dietary supplement(s). After a thorough review of all cases, a team of health professionals concluded that 489 of the 784 adverse reaction cases were more than likely (greater than 50% probability) related to taking a dietary supplement. The supplements most frequently associated with adverse events were Ephedra, Guarana, Ginseng, St. John’s wort, chromium, melatonin and zinc. In terms of severity, the investigators classified the majority reported adverse events as mild severity. Long-term users were more likely than short-term users to have a moderate or severe adverse event. Additionally, the authors found that subjects who were taking supplements with multiple ingredients had more symptoms and also had more severe outcomes than subjects taking single ingredient supplements.⁷²

A similar research article, published in the *Journal of Medical Toxicology* (2008), described the results of a 1-year prospective surveillance study regarding dietary supplement related calls to a poison control center on the West coast of the United States.⁷³ The study authors, in collaboration with the FDA Center for Food Safety and

Nutrition, noted that in the 1-year period of study, there were a total of 275 calls regarding dietary supplements received by the poison control center. The 275 calls represented .4% of all calls for the 1-year period. Of the calls regarding dietary supplements, 112 (40.7%) were from callers with symptoms, while the remainder of calls was from individuals with no symptoms, but who wanted more information regarding various supplements.⁷³

Similar to the procedure of Palmer et al. (2003), a team of health care professionals went through each individual case study to assess the likelihood that the reported event(s) were related to dietary supplement use. The authors noted that 20% of reports were judged to have had unlikely dietary supplement-adverse reaction causation, while 14% of the reports were deemed “unclassifiable” due to insufficient information. The remaining 66% of calls were judged to be either likely (2%), probably (30%) or possibly (34%) related to supplement use and thus were classified as “related.”⁷³

Looking into the results of the cases that were related to supplement use. The vast majority (85%) of related adverse events were deemed minor, similar to the findings of Palmer et al.⁷² Eight instances of supplement related adverse reactions required admission to a hospital (three into an intensive care unit). One death was also linked to supplement use; possibly due to a stroke associated with the use of several stimulant type products. The authors clustered reported signs and symptoms of adverse effects by types of supplements and also organ system. Among the findings were that stimulant type supplement ingredients (e.g. caffeine, yohimbine) most commonly caused (not inclusive) anxiety, hypertension, headache, chest pain, shortness of breath, stroke, dizziness and

agitation. Stimulants, featuring ingredients such as creatine and arginine, were also linked to gastrointestinal disturbances such as nausea, vomiting, and diarrhea.⁷³

Other supplement products or ingredients (e.g. Echinacea) were linked to hypersensitivity reactions such as rashes while products such as fish oil were linked to blood coagulation abnormalities and tryptophan and melatonin supplements were linked to drowsiness or sleepiness. Of note, caffeine-containing supplements (either single or multi-component products) were deemed responsible for nearly half (47%) of supplement related symptomatic cases while yohimbe-containing supplements (either single or multi-component products) accounted for 18% of supplement-related symptomatic cases. These results indicate that caffeine and/or yohimbe containing stimulant-based products are potentially hazardous.⁷³

Additionally, a 2013 report from the *Substance Abuse and Mental Health Services Administration* found that the number of emergency department visits involving energy drink consumption more than doubled from 2007 (10,068) to 2011 (20,783).⁷⁴ The report noted that there were more males than females admitted during this time and that the most commonly admitted age group was 18-25 year olds. Fifty eight percent (N=12,131) of energy drink related emergency room visits were due to the effects of energy drinks alone without the influence of other drugs and/or alcohol.⁷⁴ The results of this government report indicate that stimulant containing energy drinks are potentially hazardous and also that the young adult demographic (18-25 year olds) may be particularly susceptible to the dangers of these products.

Stimulant based supplements such as “pre-workout” products and energy drinks were the focus of a recent clinical review performed by Eudy and associates.⁷⁵ After a

review of the available literature pertaining to stimulant supplements, the authors noted that while there is available evidence to support the efficacy of certain ingredients (e.g. caffeine, creatine) found in these products, there is not enough evidence to support the safety or efficacy of combination products. Many of these combination products contain “proprietary blends” that do not list all of the ingredients and/or the amounts of each ingredient in the product. The authors also noted that there have been many adverse effects reported by stimulant supplement users including, but not limited to, gastrointestinal symptoms, cardiac arrhythmias, and noted increases in blood pressure. The study concluded the review article by stating, “the safety of these products may be compromised if users consume larger than recommended amounts or use more than one product.”⁷⁵ (p.577)

Additionally, there are numerous accounts of commercially available supplement products testing positive for illicit, banned, dangerous and/or otherwise unlisted ingredients.^{71, 76-80} This is of particular interest to military personnel and also athletes. Armed service members and athletes are tested for illicit and/or banned substance and can be punished for a positive test even if they are not aware that the supplements they are taking contain banned or illegal ingredients.^{81, 82} The potential for products to be unsafe and/or contaminated indicates that all supplement consumers should be consult with a medical professional prior to use, should keep up to date with trends in safety and efficacy of dietary supplements and should also approach supplement use with overall caution.

There is limited evidence pertaining to the prevalence of adverse reactions stemming from supplement use in the young adult college population of interest. Ayranci

and associates³⁰ found that of a sample of 308 university student supplement users, 26 (8.4%) had experienced an adverse event from taking a nonvitamin, nonmineral (NVNM) supplement. The most commonly cited adverse events were nausea (61.5%), vomiting (30.7%), gastrointestinal disturbances (15.7%) and flushing (11.5%). In discussing their results, the study authors noted that the prevalence of adverse reactions could be related to the fact that the vast majority of surveyed supplement users (89%) did not consult with a health care professional about their supplement use.

Another study, performed by Newberry et al,²⁹ focusing on NVNM supplement use in undergraduate college students found that 14% of supplement users reported that they had experienced an adverse reaction from a dietary supplement. Commonly reported adverse reactions for users in this particular study included increased heart rate, increased blood pressure, sleep disturbances, skin irritation and muscle soreness. Fifty-eight percent of those who reported adverse reactions continued to take the supplement(s) even after the adverse event. The study authors also noted that of the 68 supplement users who had seen a physician in the 12 months prior to the study, 28 (41%) had told their health care provider about their supplement use; however just under 10% of users reported a healthcare professional as their primary source of supplement information.²⁹ (Newberry et al., 2001). Similarly, Gardiner et al²⁷ found that only 24% of 18-30 year old dietary supplement users had discussed their use of dietary supplements with a health care professional. The findings that young adults are unlikely to turn to a health care professional for supplement information may put this demographic at an increased risk for adverse events.

Kristiansen et al,²⁴ in a study that focused on supplementation habits of collegiate varsity athletes as well as a control group of non-athlete college students, found that nearly 16% of 302 respondents (n=47) reported having experienced an adverse event after taking a supplement. Caffeine containing supplements accounted for nearly 64% of reported adverse events. Examples of noted adverse reactions after taking caffeine-containing products included nervousness, insomnia, laxative effects, headaches and an increased heart rate. Other noted supplements and associated adverse reactions included loss of energy and stomach cramping with carbohydrate supplements, feelings of an upset stomach with protein supplements and water retention with creatine supplementation. The results of this study indicated that collegiate athletes experience adverse reactions associated with supplement use, especially with caffeine containing products.

Within the Military population, Cassler et al³² found that, in a study of 329 active duty deployed Marines, 12% reported an adverse reaction as the result of taking dietary supplements. The commonly reported adverse reactions were energy crashes, jitteriness, dehydration, insomnia, acne, mood swings and anger. The study authors pointed out that the majority (79%) of respondents who reported an adverse effect were taking multiple supplements, while 89% of those who had experienced an adverse reaction were taking some form of stimulant product. In discussing their results, Cassler et al³² proclaimed, “the high rate of stimulant-based supplement use and their association with serious side effects may be an area for concern.”³² (p. 663)

Such statements from Cassler et al,³² as well as the findings of Haller et al⁷³ and Kristiansen et al²⁴ regarding the prevalence of adverse reactions stemming from stimulant based supplements, have been the subject of military case studies. Examples include a

case study performed by Young et al,⁸³ which profiled an instance of hemorrhagic stroke in a 26-year-old active duty soldier who had been taking a commonly used stimulant-based supplement and also findings of Burke and associates,⁸⁴ who profiled a soldier who developed severe rhabdomyolysis while exercising and using a different stimulant-based supplement marketed for weight loss. Both of these instances, in addition to the literature regarding adverse effects stemming from commercially available stimulant based supplements, show that some supplement products can potentially pose a danger to users.

The existing literature supports the notion that dietary supplement use has become increasingly common in recent years. People, of all ages and demographics, use many different types of supplements for many different reasons. Many dietary supplement users hold strong beliefs in the efficacy and safety of these products, despite the fact that supplements are not regulated to the same extent as other commercially available products. In the adolescent and adult populations, the literature generally supports a positive association between dietary supplement use and healthful lifestyle behaviors; however, this relationship is less clear in the young adult (collegiate) population. While existing literature has focused on such a relationship between supplement use and lifestyle behaviors in the collegiate population, much of the research is not current. With a rapidly expanding marketplace and demand for dietary supplements, current research is needed to better understand trends of supplement use within the young adult population. Such information can be of great use for university health departments, registered dietitian nutritionists, military leaders, trainers and other health professionals.

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APPENDIX A
DIETARY SUPPLEMENT SURVEY

The following survey has been modified from an existing research survey created by Dr. Kelly Beerman, PhD, Professor of Human Nutrition, at Washington State University.

The survey below is a modified version of the survey utilized to collect data for Dr. Beerman's original research study, *use of nonvitamin, nonmineral dietary supplements among college students (2001)*. The original study author has approved all changes to the original survey.

Citation

Newberry, H., Beerman, K., Duncan, S., McGuire, M., & Hillers, V. (2001). Use of nonvitamin, nonmineral dietary supplements among college students. *Journal of American College Health, 50*(3), 123-129.

Thank you for your participation in this research study. Your time is greatly appreciated.

At the end of the survey, you will have the option to take a link to additional survey, which will allow you to enter your email address to be entered into a drawing for one of four \$20 Wal-Mart Gift Cards. Please note that the participant must complete the survey in it's entirety for eligibility and also that the entering of your email is completely optional and there is absolutely no penalty for not doing so. No individual email addresses will be linked to any survey or survey responses. All responses are strictly anonymous and no identifying information is asked for or required.

General Demographic Questions

Please select your biological sex

- a) Male b) Female

Please type your height and weight

Ht _____(inches) Wt. _____(lbs.)

What is your current year in school towards completion of an undergraduate degree(s)?

- a) 1st year
- b) 2nd year
- c) 3rd year
- d) 4th year
- e) 5th year
- f) 6th year
- g) Nontraditional student
- h) Other; please specify_____

*Please note that only undergraduate students are eligible for this survey. If you are currently a graduate student, please do not proceed with the survey. Your cooperation is greatly appreciated.

Specific Demographic Questions

1) Are you currently an NCAA student athlete?

- a) Yes b) No

2) Are you currently a Military ROTC cadet?

- a) Yes b) No

Dietary Supplement Perceptions of Knowledge and Efficacy

For the Purpose of all of the questions herein contained, a dietary supplement, as defined by the FDA, is a product taken by mouth that contains a “dietary ingredient” intended to supplement the diet.

“Dietary ingredients” may include, vitamins, minerals, herbs or botanicals (plant based extracts), amino acids, and/or substances such as enzymes, organ tissues, glandulars, metabolites, constituents and or extracts.

Source:

Q&A on Dietary Supplements. (2014, March 20). Retrieved June 25, 2014, http://www.fda.gov/Food/DietarySupplements/QADietarySupplements/default.htm#what_is

After reading through the formal definition of a dietary supplement, which is presented above, the user will be taken to the following question

3. How knowledgeable are you about dietary supplements?

- a) Very knowledgeable
- b) Somewhat knowledgeable
- c) Not very knowledgeable
- d) Not knowledgeable at all

4. Do you believe that dietary supplements are effective for the following?

a. Helping to prevent certain diseases

- a) Yes
- b) No
- c) Not sure

b. Helping to treat or control certain diseases

- a) Yes
- b) No
- c) Not sure

c. Helping to increase overall health and wellness

- a) Yes
- b) No
- c) Not sure

d. Helping to maximize physical performance

- a) Yes
- b) No
- c) Not Sure

e. Helping to build muscle

- a) Yes
- b) No
- c) Not sure

f. Helping with the loss of body fat

- a) Yes
- b) No
- c) Not sure

g. Helping to increase physical appearance

- a) Yes
- b) No
- c) Not sure

Dietary Supplement Use

This section will ask the user for specific dietary supplement use information

5. Within the past 12 months, have you taken any type of dietary supplement?

- a) Yes** b) No*

*If No, user will be directed to 5a (immediately below). User will also skip questions 6, 7, 8 and 9

**If yes, user will skip 5a and will be directed to 6, which asks for supplement use information.

5a. Do any of the following reasons express why you have not taken a dietary supplement in the past 12 months? Check all that apply.

- a) Do not believe in them/feel there is no need
- b) Do not know enough about them
- c) They seem unhealthy/unnatural/have side effects
- d) Cost

e) Other; please specify _____

6. This page asks you about your use of dietary supplements. Please fill out the chart as specified in 6a-6d. *

- a) Check all supplements that you have taken within the past **12** months.
- b) For all supplements that you have taken, indicate the frequency of use by checking **only one** of the boxes in category (daily, weekly, monthly or less than monthly).
- c) On the bottom of the supplement choices page there is a list of reasons that people take dietary supplements. For each supplement you have checked, please type in the number or numbers, which best represents the reason you take/took the supplement(s). Separate the numbers with commas if more than one choice applies.
- d) Next, check either “yes” or “no” to answer whether or not you believe this supplement that you have used was/is effective. Only select a yes or no for supplement(s) that you have taken in the past year.

****Actual chart is included in an attached Excel Document. Formatting issues make it look cluttered on this word page. Please see attached document entitled “Survey Supplement List”.***

After completion of the chart, participants will be directed to question #7 and can progress through the survey.

7. On average, how much money do you spend on dietary supplements per month?

- a) < \$50.
- b) \$50-99.99
- c) \$100-150
- d) > \$150

8. Where have you received most of your knowledge about dietary supplements? **Please rate the first two greatest sources of information with a 1 and a 2.**

- a) _____ Labels on supplement containers and food packages
- b) _____ Other Health Care Professional (i.e. Medical Doctor, Chiropractor, Pharmacist)
- c) _____ Registered Dietitian (R.D.)
- d) _____ Athletic Trainer or Coach
- e) _____ Military Leader
- f) _____ Magazine
- g) _____ Television
- h) _____ Internet
- i) _____ Friends
- j) _____ Family Member(s)

- k) _____Dietary Supplement Specialty Store Associate (i.e. Vitamin Shoppe, Complete Nutrition, GNC)
- l) _____ I do not know much about dietary supplements
- m) _____ Other; please specify

9. Are there any dietary supplements that you have discontinued using?

- a) Yes
- b) No

If no, will skip 10

10. What was (were) the reason(s) that you discontinued using a dietary supplement?

Please check all that apply

- a) Felt that the product(s) were ineffective
- b) Too expensive
- c) No longer needed the supplement(s)
- d) Was recommended to discontinue taking by a health care professional
- f) Other; please specify _____

11. Have you ever experienced adverse effects from a dietary supplement product?

- a) Yes
- b) No

*If no, user will skip #11a, 11b and 11c.

11a. If yes, what were the symptoms? **Please check all symptoms you have ever experienced**

- a) Gastrointestinal distress (diarrhea, constipation)
- b) Skin Irritation (rash, itching, hives)
- c) Fever, nausea, vomiting
- d) Chest Pain
- e) Abdominal pain
- f) Pain with Urination
- g) Sleep disturbances
- h) Feelings of jitteriness
- i) Light sensitivity
- j) Headaches
- k) Other; please specify _____

- 11b. Did you continue taking the supplement(s) that caused the adverse effects?
a) Yes
b) No

- 11c. Have you discussed your experienced adverse effect(s) with a health care professional (Medical Doctor, Registered Dietitian etc.)?
a) Yes
b) No

If yes, user will skip #12

12. If no, why not?
a) Don't feel the doctor is knowledgeable about dietary supplements
b) Don't feel comfortable sharing supplement use information with a health professional
c) Don't feel that it's important to discuss
d) Other; Please Specify_____

General Health

13. Which of the following best describes your overall health?

- a.) Excellent
b.) Good
c.) Fair
d.) Poor

14. How do you feel about your weight? I am currently_____

- a.) underweight
b.) at my desired weight
c.) slightly overweight
d.) greatly overweight

Physical activity

15. Over the past 7 days, how many times did you engage in moderate or higher intensity cardiovascular activity (aerobic exercise such as jogging, biking, elliptical training, recreational sport, exercise classes, yoga, sport practice etc.) for at least 30 minutes?

- a) 0
- b) 1
- c) 2
- d) 3
- e) 4
- f) 5
- g) 6
- h) 7

16. Over the past 7 days, how many times did you engage in strength training of any type (e.g. bodyweight exercises, resistance training with machines, dumbbells, barbells or other equipment) for at least 30 minutes?

- a) 0
- b) 1
- c) 2
- d) 3
- e) 4
- f) 5
- g) 6
- h) 7

17. What are your main reasons for engaging in physical activity? (Select all that apply)

- a) Improved Overall Health
- b) Improved Physical Capabilities (Fitness)
- c) To train for sporting events
- d) To Build Muscle Mass
- e) Weight loss
- f) Weight Management
- g) To Decrease Body Fat
- h) Other; please specify _____

Diet

18. On average, how many servings of fruits and vegetables do you consume per day (combined servings, 3 servings of fruit and 3 servings of vegetables would be 6 servings total)? *

** 1 serving as defined as 1 cup of fruit or 100% fruit juice, ½ cup dried fruit, 1 small piece of hand fruit, 1 cup of raw or cooked vegetables, 2 cups of green leafy vegetables or 1 cup of vegetable juice*

- a) 0
- a) 1-2
- b) 3-4
- c) 5-6
- d) 7 or more

19. On average, how many days per week do you consume breakfast?

- a) 0
- b) 1
- c) 2
- d) 3
- e) 4
- f) 5
- g) 6
- h) 7

20. How would you rate the overall quality and adequacy of your current diet?

- a) Poor
- b) Fair
- c) Good
- d) Excellent

Alcohol

21. On average, how many alcoholic drinks do you consume per week (*1 drink defined as 12 oz. of beer, 5 oz. of wine or 1.5 oz. of 80 proof (40% alcohol by volume) liquor*)?

- a) 0
- b) 1-4
- c) 5-8
- d) 9-12
- e) 13-15
- f) 16-20
- g) 21 or more

22. On average, how many days per week do you consume at least one alcoholic beverage?

- a) 0
- b) 1
- c) 2

- d) 3
- e) 4
- f) 5
- g) 6
- h) 7

23. On average, on how many occasions per week do you consume 5 or more alcoholic drinks within a two-hour span (4 or more drinks within the same amount of time for women)?

- a) 1
- b) 2
- c) 3
- d) 4
- e) 5
- f) 6
- g) 7
- h) 8 or more

Tobacco

24. Have you used any tobacco product within the past year?

- a) Yes b) No

If no, user will bypass question #26

25. How would you describe the frequency of your tobacco use?

- a) Habitual; Daily
- b) On occasion (once a week)
- c) On a very rare occasion (once a month)
- d) Less than monthly
- e) Extremely rare

1. Debriefing Statement

Thank you very much for your participation in this survey; your time is greatly appreciated. If you would like to contact the survey author for any additional information, Arthur A. Valentine, FCS Graduate Student, can be reached at (651)-492-2079 or aavalen@ilstu.edu

If you have any questions, comments, or concerns regarding your rights as a participant, please contact the Research Ethics & Compliance Office at (309)-438-2529 or rec@ilstu.edu

If you would like to enter your email to become entered into a drawing for one of four \$20 Wal-Mart gift cards, please follow the link below to a separate survey. Please note that proceeding to the link below is completely voluntary and is in no way required, also, if you do choose to enter your email address please be aware that your email information will not be attached to any survey or to any survey responses so as to maintain complete anonymity. Once again, thank you for your time.

<Insert Link>

Highest regards,

Arthur A. Valentine, B.S.
Dietetics Graduate Student
Dietetic Intern
aavalen@ilstu.edu

APPENDIX B
RESEARCH QUESTIONS TABLE

Research Question(s) (within each independent population: Undergraduates, student-athletes, and cadets)	Independent Variable	Dependent Variable	Items on Survey	Analysis Method
<ul style="list-style-type: none"> • What percentage of respondents reported the use of at least one DS within the 12-month period prior to survey administration? • What is the average number of supplements taken? • What percentage of users reports the use of 1-4 supplements, 5-10 etc.? • Which supplements are most (and least common) within each group? • What reasons do DS users report for use? • Why do non-users <i>not</i> use DS? • How much do DS users spend (per month) on DS? • What are the primary sources of DS information? • What percentage of users has discontinued the use of at least one DS? Why? • What percentage of users has experienced an adverse event as the result of DS use? Did they discuss with a health care professional? If not, why? • Do users believe in the efficacy of the individual types of DS they choose to take? 	Grouping Variable (Undergraduate, student-athlete, or ROTC)	DS Use (both overall DS use and use of individual types of DS)	Demographic questions + Supplement Use Questions	Prevalence statistics
<ul style="list-style-type: none"> • • • Does overall or 	Gender, year in school	DS Use (both overall	Demographic Questions	Chi-square

individual DS use vary by gender, year in school or body mass index (BMI)	towards completion of a degree, BMI (calculated from self-reported height and weight)	DS use and use of individual types of DS)	+ Supplement Use Questions	independence tests (χ^2) and Fisher's exact testing for low expected cell counts (<5)
<ul style="list-style-type: none"> How many students report being knowledgeable about DS? Is there a difference in self-reported levels of knowledge between DS users and non-users? 	Status as a DS user or non-user	Perceptions of DS knowledge (e.g. somewhat knowledgeable, very knowledgeable)	Supplement Use Question + Knowledge about DS question	Chi-square independence tests (χ^2) and Fisher's exact testing for low expected cell counts (<5)
<ul style="list-style-type: none"> How many students believe in the efficacy of DS for different conditions (e.g. muscle building, fat loss) Is there a difference in efficacy beliefs between DS users and non-users? 	Status as a DS user or non-user	Perceptions of DS efficacy for seven different conditions (e.g. muscle building, fat loss)	Supplement Use + Perception of Efficacy Questions	Chi-square independence tests (χ^2) and Fisher's exact testing for low expected cell counts (<5)
<ul style="list-style-type: none"> Do lifestyle behaviors differ between DS users and non-users? 	Status as DS user or non-user	Self-reported lifestyle behaviors (e.g. physical activity, diet, alcohol, tobacco)	Overall DS Use Question + Lifestyle Behavior Questions	Chi-square independence tests (χ^2) and Fisher's exact testing for low expected cell counts (<5) for categorical data and independent samples t-tests for continuous data

APPENDIX C
RECRUITMENT EMAIL

Recruitment Email

Hello, my name is Arthur Valentine and I am a graduate student under the supervision of Dr. Julie Raeder Schumacher, Dr. Jan Murphy and Dr. Yoon Jin Ma with the department of Family and Consumer Sciences. I invite you to participate in my research study regarding dietary supplement use, perceptions and associated lifestyle behaviors in college students.

The purpose of this research study is to gain a better understanding of the prevalence of dietary supplement use, the types and amount of supplements that college students are taking, the perceptions that university students hold regarding efficacy and safety of dietary supplements, as well as identifying which lifestyle behaviors are associated with dietary supplement use or non-use in the populations of interest.

Your participation will be of great benefit to the study authors' goal of adding to the literature regarding current trends in dietary supplement use.

This survey contains 26 questions and should take no more than 15-20 minutes to complete. You will be able to skip any question within the survey and/or may exit the survey at any time without any penalty. Your answers are completely anonymous and no identifying information will be required.

After completing the survey, you will have the option to enter your email address into a separate survey to then be entered into a drawing for one of four \$20 Wal-Mart Gift Cards.

If you are interested in taking part in this survey study, and are 18 years of age or older, an undergraduate college student, NCAA student athlete and/or an Army ROTC candidate, please follow the link below.

<Insert Link>

Thank you for your time,

Arthur A. Valentine
Dietetics Graduate Student
Dietetic Intern
aavalen@ilstu.edu

APPENDIX D
INFORMED CONSENT DOCUMENT

Dear participant:

My name is Arthur Valentine and I am a graduate student under the direction of Dr. Julie Schumacher, Dr. Jan Murphy and Dr. Yoon Jin Ma with the department of Family and Consumer Sciences. I am conducting a research study regarding dietary supplement use, perceptions and associated lifestyle behaviors in selected university populations.

I am requesting your participation in this research study. Before proceeding, please take a minute and read through the following information.

What follows is a web-based questionnaire that should take no longer than 15-20 minutes to complete in its entirety. Please answer all questions truthfully and to the best of your ability. You will have the option to skip any question that you do not wish to answer. You will remain anonymous throughout the course of the survey and no identifying information, such as your name, e-mail address, or telephone number will be required.

While it is not required, you will have the option to enter your email upon completion of the survey to be entered in a drawing to win one of four \$20 Wal-Mart Gift cards. If you would not like to be entered to win one of the prizes, simply do not follow the link after completion of the survey to enter in your email address for eligibility.

You will encounter no more risk by completing this survey than you would in regular everyday life. The questions are asked in a non-judgmental manner and will not be used in any way against any participant; nor will any identifying information such as name or age be required or released to any faculty, coaches, or military leaders.

This survey is completely anonymous and also does not ask for any information regarding the use of anabolic steroids or any other illegal performance enhancing drug(s) as declared illegal by government agencies such as the FDA or DEA or institutional governing bodies such as the NCAA. One type of featured dietary supplement, caffeine either as a singular supplement or as an ingredient in a multiple-ingredient stimulant product, is currently banned by the NCAA when found in elevated concentrations in the urine (urine test must exceed 15 mcg/dL) however, due to the complete anonymity of the survey, there is no risk for an NCAA athlete declaring the use of caffeine containing products on this survey.

Additionally, there are questions regarding the consumption of alcohol but because of the complete anonymity of the survey, and because the survey does not ask for an age, the completion of this survey poses absolutely no risk of any punishment for consuming alcohol for any reason including, but not limited to, being underage (<21 years of age).

Participation in this study is completely voluntary and you will be able to exit the survey at any time without any penalty. You may also skip any question that you do not desire to

answer and move onto the next. If you exit the survey before completion, your answers will not be counted and will not be used for data analysis.

You must be aged 18 or older and also either a full-time undergraduate college student, an NCAA student-athlete or a student Army ROTC cadet to participate in this research study. If you are a varsity athlete or an ROTC candidate, please check the applicable box on the survey.

If you have any questions, comments or concerns, regarding this study, please do not hesitate to inquire the survey author, Arthur A. Valentine, FCS Graduate Student, at aavalen@ilstu.edu or 651-492-2079.

You may also contact the Supervising Faculty Members, Dr. Julie Raeder Schumacher at jmraede@ilstu.edu ;(309)-438-7031, Dr. Jan Murphy at Jshane@ilstu.edu; (309) -438-3558 or Dr. Yoon Jin Ma at yjma@ilstu.edu; (309) 438-7935. If you have any questions regarding your rights as a participant, please contact the Research Ethics & Compliance Office at (309)-438-2529 or rec@ilstu.edu

Your time is greatly appreciated. Thank you so very much.

Sincerely,

Arthur A. Valentine

Agreement

Your response below indicates your consent to participate in the study:

Please indicate by checking the box in the appropriate place for you.

_____ **Yes-** I agree to participate in the study and am over 18 years old

_____ **No-** I do not wish to participate or I am <18 years old