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# Contribution of Dietary Supplements to the Nutritional Status of College Students

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## List of Abbreviations

| | |
|---|---|
| ADA | American Dietetic Association |
| AI | Adequate Intake |
| AS | anabolic steroid |
| BMI | Body mass index |
| CATCH | Child and Adolescent Trial for Cardiovascular Health study |
| CSFII | Continuing Survey of Food Intake by Individuals |
| DR | Diet Recall |
| DRI | Dietary Reference Intake |
| DSHEA | Dietary Supplement Health and Education Act |
| EAR | Estimated Average Requirements |
| INTERMAP | International Population Study on Macronutrients and Blood Pressure |
| NCC | National Coordinating Center |
| NDSR | Nutrition Data System for Research |
| NHANES | National Health and Nutrition Examination Survey |
| NVNM | nonvitamin, nonmineral |
| RDA | Recommended Dietary Allowance |
| UConn | University of Connecticut |
| UL | Upper Limit |
| VITAL | VITamins and And Lifestyle study |
| VM | vitamin-mineral |

**Abstract**

Little is known about the prevalence of dietary supplement usage among college students. Though taking dietary supplements can cover nutrient shortages not achieved through diet alone, it is often recommended to improve the quality of one's diet rather than rely on supplements. The main objective of this research study was to determine the prevalence of dietary supplement use among college students in relation to a variety of demographic and lifestyle variables, and to find out what portion of total nutrient intake is supplied by supplements. Subjects were all recruited from the University of Connecticut, and each participant completed a health and nutrition survey plus a 30-day diet recall. A T-Test was completed to compare nutrient adequacy between supplement users and non-users using dietary data averaged over 30 days. The study showed that despite nearly 40% of students using supplements, many female students are falling short in iron. Several critical nutrients, including fiber, vitamin D, E, calcium are also lacking in the diets of most college students.

## 1. Literature Review

### 1.1 Introduction

Nutrient supplements are a broad category of food regulated by the Center for Food Safety and Applied Nutrition of the Food and Drug Administration. The Dietary Supplement Health and Education Act (DSHEA) defines a supplement as a product intended to supplement the diet by increasing intake, which might consist of, but not limited to: a vitamin, mineral, herbs or botanicals, an amino acid, a concentrate, metabolite, extracts, enzymes, or a combination these ingredients[1].

The American Dietetic Association (ADA) encourages eating a varied diet as the best way to maintain health and prevent disease rather than using supplements[2]. However, not all Americans are consuming the recommended daily servings of fruits and vegetables to cover their micronutrient needs[2]. Many nutrients now have a Dietary Reference Intake (DRI) established, and people are becoming more concerned about meeting these needs. Dietary reference intakes also define the Estimated Average Requirements (EAR), Recommended Dietary Allowance (RDA), Adequate Intakes (AI), and the upper limits (UL) of intake without risking harmful effects of overdose[11]. Though supplements may be useful as added "insurance" for filling in nutrient gaps caused by inadequate intake, there is always the risk of putting one in excess of the UL. However more information is needed on the types of supplements Americans are using in relation to their nutritional status. Furthermore, whether or not taking supplements are helping Americans meet their DRI or putting them in excess of certain nutrients requires further research.

It is important to investigate whether or not taking supplements will actually enhance the nutritional status of individuals, and what proportion of people's total nutrient intake is supplied by supplements. The purpose of this review is to explore the trends that exist about dietary

supplement usage in a variety of people, differing by age, gender, and lifestyle, and to draw logical conclusions about supplement use in the target population—college students.

### 1.2 Overview of Dietary Supplementation in the United States

One review[3] documented some trends in supplement usage in different populations of the United States, and found that some adults and adolescents with poor intakes of nutrients from food were not as likely to be supplement users as those with high intakes. National surveys reported an increasing trend of supplement usage. The National Health and Nutrition Examination Survey (NHANES) 1988-1994 showed a prevalence rate of 40% nationally, compared with 23% in NHANES 1971-1975 and 35% NHANES 1976-1980[3]. It was also reported that adults and adolescents who *were* supplement users not only have high nutrient intakes from food, but also may be at risk for excessive intake as well[3].

The NHANES 1999-2000 collected data on lifestyle behaviors, health, diet, and supplement usage of a representative sample of the US population over 20 years[4]. The survey included 4,862 adults, 52% of whom were found to have taken at least one supplement in the past month. Nationally, the most commonly used supplements included multivitamin/multimineral (35%), followed by vitamin C, E, and calcium[4]. There was also a greater supplement usage rate among those with under or normal weight status, and a high activity level (versus no activity). It was also found that there were higher usage rates among white, highly educated women[4]. This study deserves merit since it gives a good representation of national supplement usage, but since the survey was done over ten years ago, it is likely that the established trends in supplement usage may have changed since then.

### 1.2.1 Nutrient Adequacy in United States

As part of the integrated dietary component of the *What We Eat in America* NHANES 2001-2002 survey[5], nutrient intakes were estimated with food consumption data obtained from 24-hour diet recalls (DR). Figure 1 summarizes the average percent of surveyed Americans with inadequate intakes of many essential nutrients, including vitamin E, magnesium, and vitamin A.

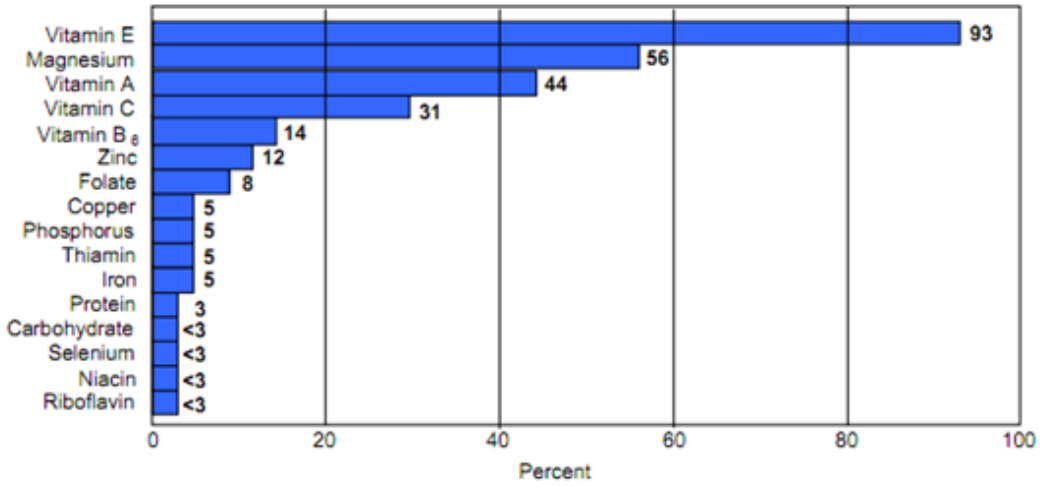


**Figure 1. Percentage of Americans with Inadequate Intakes from Food Based on Estimated Average Requirements**

Data source: What We Eat in America. NHANES 2001-2002. 1-day, individuals 1+ years, excluding breast-fed children and pregnant or lactating females[5].

It was shown that many individuals fall below the EAR for vitamin A, E, C, and magnesium[5]. Vitamin B6 (only for females over 50 y), and zinc (for older adults and teen females) were only low for certain members of the population[5]. Only 25% of Americans are meeting their AI for vitamin K and calcium, and females were less likely to meet their AI for calcium than males. Less than 5% of the population had adequate intakes of dietary fiber and

potassium[5]. It is important to focus on these nutrients in particular when evaluating the current intakes of college students, and if taking supplements improves their deficiency status.

### 1.2.2 Supplement Usage in Various Ethnic Groups

There is a definite trend between ethnicity and supplement usage. According to a cultural study about dietary supplement use by Jasti et al[6], minority groups compose about 29% of the US population. This group includes African Americans, Hispanic, Asian, Pacific Islander, Native American, and Alaskan. Data from the 1994-96 Continuing Survey of Food Intake by Individuals (CSFII96) provided a representative sample of the US population throughout all 50 states. A total of 23,700 people took the survey and completed two single-day DR. It was discovered that higher proportion of supplement users were white women (57%, $P< 0.01$), diagnosed with a disease (36%), on a diet (20%), or had a higher income and education[6]. These results show that the populations in the US who are most at risk for nutritional deficiency are not likely to take supplements[6]. In addition, many minority groups have a lower education level and have poorer health status than non-minority groups[6]. There is not much existing research on dietary supplement usage among minority groups. Further research on these nutritionally vulnerable population groups is necessary.

Foote et al.[7] also surveyed dietary supplement use among a multiethnic cohort consisting of African American, Native Hawaiian, Latino, Japanese-American, and white adults in Hawaii and Los Angeles. 11,812 participants were surveyed on regular supplement use, demographic, lifestyle, and other related factors. Their results were similar to the findings by Jasti et al.[6]. Supplement use was fairly high among all ethnic groups, but especially among whites[7]. Females with a higher education level, higher physical activity (> 3 times per week), and greater fiber and fruit intake were more likely to take supplements compared to those who had a lower education

level, no physical activity, and ate little fiber and fruit[7]. On the whole, these two multiethnic studies[6,7] demonstrate a high rate of supplement usage among highly educated, white women who frequently exercised and ate healthy diets.

### 1.2.3 Other Factors that Affect Supplement Usage

Regular exercise and weight perception may affect how often people take dietary supplements. In a cross-sectional Brazillian study by Goston et al.[8], 1102 people from 50 gyms were surveyed about their lifestyle and supplement usage. Two studies[14,17] found that frequent exercisers consumed supplements more frequently than non-exercisers. Thirty-seven percent of participants took at least one supplement, and that men were actually more likely to take supplements than women (45% vs. 28 %; $P< 0.01$)[8]. Men were also more likely to take protein and branched chain amino acid supplements, while women tended to consume multitivitamins, phytotherapeutic agents, and meal-replacements[8]. Overall, it was concluded that people who exercise regularly were highly likely to take supplements, even though they were already engaging in healthy eating and exercise habits[8].

Supplements may also be used for weight loss. As people are becoming more conscious about their health, more people are also turning to supplements to help quickly lose weight[9]. Pillitteri et al.[9] examined supplement usage among 3,500 adults over age 18 y. It was found that 33.9% of adults who attempted weight loss had also tried using supplements[9]. Contrary to previous studies[7,8], there was frequent supplement usage among young adults and lower-income individuals[9]. People who were overweight and concerned about their weight status were also more likely to use supplements to aid in weight loss[9]. These studies show exercise level[7] and weight perception[9] are both important predictors of supplement usage. Those who exercise

frequently may use supplements to enhance their health, while those who are concerned about their weight use them as well, despite misperceptions about the safety of these products[9].

### 1.3 Dietary Supplementation in Various Age Groups

Though surveying a large varied population may give some insight into their health status, examining specific age groups could give a better picture of supplement use trends.

#### *Adults*

A cross-sectional study from the VITamins and And Lifestyle study (VITAL) in 2000-2002 examined the usage of various supplements and cancer incidence in 45,748 (ages 50-75 y) men and women in Washington state[10], and compared micronutrient intakes among them. The subjects completed a questionnaire on the types and frequency of supplements used, and any serious medical conditions. The most frequently reported supplements used were multivitamins, vitamin E, and calcium[10]. Women with higher education, and were Caucasian or Native American were most like to take supplements in general, and people with chronic medical conditions were also more frequent supplement users than people who didn't have any health conditions[10].

Archer et al.[11] assessed specific micronutrient intakes with dietary supplement usage among 2,195 men and women (ages 40-59 y). The International Population Study on Macronutrients and Blood Pressure (INTERMAP) sampled eight diverse population samples in the United States. In this international, cross-sectional, epidemiological study, 52% of the subjects reported the usage of supplements, with more women than men using supplements (56% vs. 46%). Asian Americans were the most frequent users (63%), while Hispanic and African Americans were least frequent users (39%)[11]. Among the most frequently consumed

supplements were calcium, vitamin C, E, B-6, and B-12, while gingko biloba, ginseng, and bioflavonoids were common among herbal supplement users. Food intakes of A, C, E, niacin, and folate were noticeably higher in supplement users compared to non-users[11]. Some supplement users also had intakes of phosphorus, iron, magnesium, selenium, and zinc that exceeded 100% of the EAR[11]. Taking supplements might enhance the nutrient intakes of individuals who took them, but at the same time puts the user at risk for greatly exceeding the daily requirements for that nutrient.

Knudtson et al.[12] studied nonvitamin, nonmineral(NVNM) supplement use in an older population, 43-86 y (n = 4,926) from 1988 through 2005. Researchers found a drastic increase in NVNM usage during the study period; usage increased from 5% in 1988 to 30% in 2005. It is worthy to note that a significant increase in NVNM usage occurred during the 1994 passage of the DSHEA[11]. NVNM supplement users were also likely to take vitamins and minerals, lead a healthier lifestyle (non-smoking, frequent exercise, etc), and have lower mortality rates during the study period than non-users[11].

***Children and Adolescents***

Adolescents are also frequent group of supplement consumers. According to a review by Dorsch et al.[13], there are many factors that may affect supplement usage in adolescents, including health status, gender, and level of physical activity. Supplement use in adolescents can range from 10% to 74%, so it is important to be aware of the nutritional status and knowledge of supplement use in this population[13].

A sample of 10,828 children (ages 2-17 y) from the NHANES 1999-2004 were surveyed not only for vitamin-mineral (VM) supplement usage, but also nutrition, physical activity, and

demographics[14]. About a third of all subjects used at least one vitamin or mineral supplement. Moderate physical activity was directly correlated with VM usage[14]. Users of VM supplements also had higher fiber, lower fat, and lower cholesterol diets, which shows that users may also be more health-conscious than non-users[13]. Underweight children and adolescents were more likely to take VM supplements than those who were not underweight[14]. Stang et al.[15] also studied dietary supplement use and adequacy among 423 adolescents. Like the previous study by Shaikh et al.[14], about 33% of adolescents used supplements. Frequent supplement users had higher average intakes of several different micronutrients than nonusers, and were also more likely to eat nutrient-rich diets[15]. Dietary intakes of vitamin A, E, calcium and zinc were low (<75% RDA) among both supplement users and nonusers[15]. The third Child and Adolescent Trial for Cardiovascular Health(CATCH) study did a cross-sectional, observational study on 1,532 eighth-grade students, and studied the influence of VM product usage on their actual nutrient intakes. They found that supplements contributed half of the vitamin C, D, and E, but only a fourth of the RDA for iron and zinc[16]. Consistent with previous findings[14,15], supplements users made healthier food choices, and had higher intakes of vitamins and minerals from diet alone than non-users[16]. VM usage would certainly benefit individuals whose diets failed to meet the RDA for certain micronutrients. Researchers also concluded that taking VM supplements will not likely improve health if a person was already consuming sufficient quantities of micronutrients to cover their daily needs[16].

Bell et al.[17] examined supplement use and knowledge in 333 adolescents in high schools in western Canada. The authors found that multivitamin/mineral supplements were the most popular among both males (42%) and females (43%), closely followed by protein supplements[17]. There was a correlation between physical activity level and supplement use; those engaged in

more physical activity indicated that they were more likely to use creatine and protein supplements than non-users[17]. Females used more herbal weight control products to lose weight, while males were inclined to use protein and creatine to enhance performance or gain weight/muscle mass[17]. In another study by Hoffman et al.[18], researchers examined supplement usage and anabolic steroid (AS) use in high school students from grades 8-12 in the United States. Multivitamins and body mass gaining supplements (protein powder, amino acids, creatine) were the most popular among the students. Seventy-one percent of the surveyed students reported use of at least one supplement, and the supplement use trend increased across grade levels. More males tended to use anabolic steroids as well. This study highlights the importance of providing education on drug use to adolescents so they will understand the advantages and disadvantages of its use.

In review, adult supplement users tend to be women, highly educated, and have more income than non-users[4,6,7]. They were also found to use supplements if they had a medical condition[6,10]. On the other hand, adolescents tended to use supplements to lose weight or enhance performance[17,18]. Adolescents also were likely to use supplements if they ate a healthful diet, exercised frequently, or were health conscious[14,15,16]. Since college-age students lie in the transition from adolescence to adulthood, it might be expected that their rationale for taking supplements may be a combination of both.

***College Students***

With the possibility of gaining muscle mass and improving physical performance, it is no wonder many student athletes choose to take a dietary supplement. A 2009 study by Dascombe[19] and colleagues reported on nutritional supplementation habits of athletes in a state-based sporting institution in Australia. Eighty-eight percent (63 out of 72) athletes reported using a supplement.

Only half of the supplement-using athletes demonstrated that they had in-depth knowledge about the supplements they were taking[19]. *More* athletes seemed to receive supplement information from allied health professionals than any other source. The most frequently used supplements were vitamins (43%), minerals (46%), and iron (31%). Though frequency of supplement intake was relatively similar for males (89%) and females (86%), the *types* of supplements were different[19]. Females used more vitamin, mineral, and iron supplements for "improving energy and health", while males used more caffeine, creatine, and protein-carbohydrate supplements for "improving performance, energy and immunity"[19].

An older study by Newberry et al. in 2001[20] reported on nonvitamin, nonmineral (NVNM) supplement usage in college students in the US. Their aim was to determine the trends in supplement usage in the college population, to observe demographics and perceived benefits, and to compare lifestyle habits of these students. A representative sample of 158 women (ages 23 ± 4.9 y) and 114 men (ages 23.1 ± 4 y) responded to the survey. 132 (49%) of respondents reported that they took at least one NVNM supplement. The most commonly consumed NVNM supplements included echinacea, ginseng, gingko biloba, and St. John's wort[20]. There were no differences in exercise habits between individuals taking ergogenic supplements and those who didn't take supplements to enhance performance. Men actually tended to take NVNM more often than women for performance enhancement reasons[20]. Women were likely to take supplements for losing weight or relieving anxiety. It can be noted that college students use supplements not to treat existing health issues as adults do[11,12], but instead to lose weight or enhance health or athletic performance[20]. Though these findings are most relevant to the objectives of the present study, the results are nearly 10 years old and are in need of an update.

Perkin et al.[21] validated the results of the study by Newberry et al.[20] through another college student survey on nonvitamin, nonmineral supplement supplement usage. They aimed to determine the prevalence of supplement usage among college students, as well as the frequency and justification of usage, and to find out where they receive supplement information from. A much larger body of 1000 (607 women, 385 men, average age 26 y) students were given a 15-item questionnaire on NVNM supplementation. 26% (263) students recounted current usage of NVNM supplements, and ginseng (30%), echinacea (28%), protein powder (23%), gingko biloba (21%), and St. John's Wort (18%) were the most frequently used supplements among the 263 users[21]. Many students received supplement information from friends and family. Women were more likely to use supplements for weight loss, while men used supplements for performance enhancement or body building[21].

Many past studies document evidence of the dietary supplement patterns of college students[19,20,21], however there are not many studies that show exactly *how much* dosage each person is consuming. Stasio et al.[22] examined the relationship between over-the-counter medication and dietary supplement use in relationship to distress in college students. 201 students (125 female and 76 male, average age 22.3 y) participated in the study. Their results showed that a majority (74%) of college students were taking OTC medications, and 70.4% were taking at least one dietary supplement (herbal, vitamin, or mineral)[22]. There was a positive correlation between dose frequency of OTC drugs and reported emotional distress and anxiety[22]. This study shows increasing rates of pharmacotherapy and drug usage among college students, which warrants further investigation.

### 1.4 Conclusion

In summary, supplement usage has become increasingly popular in recent years, and people of nearly all ages have been shown to use supplements. Adults and older individuals who take supplements tend to be female, white, and have higher education than non-users[4,6,7]. Adolescents are a group of young people who may be just starting to explore the world of supplements, and studies have shown that about a third of all teenagers are using dietary supplements[14,15,16]. College students also have high rates of supplement usage, especially among student athletes[19]. As with adolescents, college women were likely to use supplements for weight loss or to improve energy, while men were inclined to supplement themselves to enhance athletic performance or gain muscle[19,20,21].

## 2. Specific Aims

Most of the existing literature on supplement use in college students is largely outdated or only focused on NVNM usage instead of *all* the supplement types. This study will investigate the dietary supplement usage in the college population at the University of Connecticut. The purposes of this project are to 1) report the status of supplement usage among male and female college students, 2) document the types of supplements used, as well as any correlations with gender, lifestyle, demographics, physical activity, and body mass index (BMI), and 3) to investigate whether or not taking supplements will actually improve the nutritional status of individuals, and to determine which portions of total nutrient intake is supplied by supplements.

## 3. Approach

### Subjects

The Antioxidant Study was conducted in the spring of 2010 in order to acquire more information about the nutritional status of college students, specifically the impact of antioxidants on health status. As part of the larger study, this project specifically focused on the intake of supplements and their contribution to nutrient adequacy. Recruitment began at the University of Connecticut (UConn), Storrs in introductory nutrition classes but later extended to other larger classes. Subjects were also recruited by emails and flyers which were posted in various academic buildings. A total of 77 subjects were recruited based on inclusion criteria and interviewed, but retained only 60 students who provided 30 day DR. 16 subjects were excluded from data analysis due to miss-reporting. After testing the miss-reporting, 44 subjects, (27 female, 17 male, 18-25 y) were included in the final study. No subjects were included if a student was taking prescription medications or had long-standing illnesses. The study subjects were all healthy individuals for their age, weight, and BMI.

**Data Collection**

All subjects reported to the Jones Building laboratory at the UConn Storrs campus, where their anthropometric and other assessments were taken by trained individuals. Each subject completed a Health and Nutrition survey that included questions about their major, standing in college, dietary restrictions, perceptions about body weight, physical activity, and supplement usage. If a subject indicated that they took supplements, the type, dosage, and frequency of use were noted in further detail. In addition, subjects submitted 24-hour DRs for 30 consecutive days. All food consumed during the period of study was entered using the Nutrition Data System for Research (NDSR) software (version 2009, Nutrition Coordinating Center (NCC), University of Minnesota, Minneapolis). Intake of 16 different macro and micronutrients from all foods consumed was computed and then averaged over 30 days. A subject was

considered a supplement user if they took at least one supplement once a week. Supplements encompassed items purchased over the counter intended to supplement the diet, as defined by the DSHEA[1], and included but are not limited to vitamins, minerals, protein, and herbal products. Foods that are fortified with vitamins and minerals were not counted as supplements, and these foods included vitamin-enhanced drinks, fortified cereals, and nutrition bars. Each supplement a subject took was entered separately into the NDSR database. The additional nutrients supplied by supplements was computed by multiplying the frequency by dosage amount, and averaged over 30 days. Table 1 shows the characteristics of the study population among supplement users and non-users. In addition to quantitative data such as body weight, BMI, and age, responses to several survey questions regarding dietary restrictions, weight perception, and physical activity level are also presented as percentage of total respondents. Prevalence of usage of all types of supplements taken by male and females is displayed in Table 2. A frequency table, Table 3, was constructed by counting the average number of times each type of supplement was taken over the course of a month (1-2x/month, 1x/week, 2-3x/week, or 4-6x/week). Many subjects took more than one type of supplement, and if a supplement contained multiple components such as vitamin B-complex plus vitamin C, they were counted as two separate categories of supplements. Tables 4 and 5 were made using DR data of male and female subjects averaged over 30 days from NDSR software. Data from diet only and diet plus supplements were included for supplement users. For comparison purposes, nutrient intake from non-users was also added.

**Statistical Analysis**

A student t-test was completed using Microsoft Exel to compare differences in average nutrient intake between supplement users and non-users. The t-test was used also to compare differences in nutrient intake within the group of supplement users. For nutrients that have an

RDA, AI or UL, percentages of subjects whose intake meet or exceed these values were also evaluated.

## 4. Results

### 4.1 Socio-demographic and lifestyle characteristics of respondents

Table 1 compares a few demographic characteristics, BMI, dietary restrictions, weight-related characteristics, and the level of physical activity of supplement users and non-users. The percentage of male and female users is 53% and 47%, respectively, while 60% of non-users are female. The vast majority (94%) of users were Caucasian, while only 66% of non-users were Caucasian. Most users and non-users had a BMI in the normal range of 18.5-24.9 (76% and 78%, respectively). There was a lower percentage of users who were pressured to be a certain weight (29%) than non-users (56%). Fewer supplement users skipped meals to lose weight (12%) than non-users (22%). A high percentage of both users and non-users engaged in moderate activity, but more users partook in *vigorous* activities than non-users (94% vs. 74%).

### 4.2 Prevalence and frequency of supplement usage

Table 2 lists all the different types of supplements taken by college students and the percentage of male and female users who consumed each type. Overall, 38% (n=17) of all surveyed students reported usage of at least one supplement. Among all 44 subjects, 8 female (18%) and 9 male (20%) reported use of one or more supplements per month. The most frequently taken supplement by female students was the multivitamin (75%), but far more males took protein (66%) compared to females (13%). Females also took more iron (38%) and calcium (25%), but males took a variety of NVNM supplements, such as quercetin (11%), green tea (22%), and fish oils (22%). The frequency of different types of supplement usage over the course of a month is summarized in Table 2. 56 different accounts of supplement usage were

divided unevenly among the major categories of multivitamin, protein, individual vitamins, B-vitamin complex, and NVNM supplements. Multivitamins were taken the almost daily, or 4-6 times per week for half of multivitamin users, while 30% only took it once or twice during the entire month.

### 4.3 Contribution of Dietary Supplements to Total Nutrient Intake

Supplements contributed different nutrients for male and female users. For the 8 female supplement users, intakes vitamins C, D, α-tocopherol, calcium, iron, and folate were significantly higher ($p < 0.05$) than the 19 non-users from foods alone (e.g. total average vitamin A intake for supplement users was 1045 µg/day, while from non-users diet alone it was 817 µg/day). 63% of supplement users and 79% of non-users still do not meet the AI for fiber for females. Before supplementation, all subjects fell below the RDA for vitamin D, but with supplementation 50% of users were able to meet their daily requirements. The percentage of female students with intake of α-tocopherol below the AI significantly decreased after supplementation, from 88% to 25%. Supplement users had a much higher intake of calcium than non-users (891mg vs. 1343mg). Differences for other nutrients such as protein, potassium, and selenium were not significant.

For male students, the total nutrient intake differences between non-users and users were not as noticeable as the female students. There was no significant difference in protein intake between users and non-users ($p > 0.05$). Only magnesium and α-tocopherol intakes were significantly higher among supplement users than non-users ($p < 0.05$). More than half of users and 100% of non-users did not meet the AI for fiber. Supplement use did not increase vitamin A intake to a great extent, as still one-third of all male subjects did not meet the AI for this vitamin. More than three-fourths of males fell below the AI for vitamin D and potassium, even among

supplement users. 33% of supplement users and 50% of non-users were still below the RDA for calcium, though intakes of calcium of users and non-users were relatively similar (1383 mg/day vs. 1201 mg/day).

## 5. Discussion

The present study found that 38% of all 44 participants were taking at least one supplement, of which 18% were female and 20% were male. The prevalence of supplement usage in this study is much lower than expected from previous studies in students[19,20,21], where it was reported that 48.5% of students took at least one NVNM supplement[20]. However, many of the past studies only looked at the NVNM variety, and not supplements in general. There were a few differences in the types of supplements taken by males and females. The top three supplements taken by females were multivitamin (75%), vitamin C (38%), and iron (38%), while the three for males were protein (66%), multivitamin (44%), and vitamin C (33%). This pattern is similar to the most prevalent supplements taken by college athletes in another study[19], most notably multivitamin/minerals and iron by females, and protein and energy-boosting supplements. In this study, a higher percentage of female students took iron supplements than males (38% vs 11%), and only male students were taking caffeine supplements, presumably for boosting energy. Consistent with a previous study in adolescents[17], male students were most likely to be taking different kinds of protein supplements to build body mass.

Findings for the frequency of use yielded interesting results. Individual vitamins and minerals (including zinc, vitamin C, vitamin D, iron, and calcium) were taken the most often by all the participants-a total of 18 times, and accounted for 32% of total uses. Though multivitamins was one of the most prominently taken supplements, it only accounted for 18% of total uses. Individual B vitamins and B-complex were the least frequently taken supplements,

and all of them were taken once a week on average. More than a third of the individual vitamin and mineral supplements were taken once a week, on average. There does not appear to be a major pattern in the frequency of protein supplement consumption.

It was found that 94% of supplement users were Caucasian, which is comparable with findings from previous studies[6,7], which report a high incidence of supplement users who were highly educated and were white. However, there was about the same percentage of male users as female users, which is inconsistent in studies with adults[10,11] that find more female users than male users. On the contrary, adolescent studies[16,17] find about an equal proportion of male and female supplement users.

Unlike a previous study that found that most supplement users were underweight in the adolescent population[14], our supplement study found that about three-fourths (75%) of users fell in the normal BMI range (18.5-24.9 $kg/m^2$) and most were not afraid of weight gain or pressured to be a certain weight (71%). There was little evidence in the data to suggest a relationship between body weight and supplement usage. Many people who use dietary supplements are also frequent exercisers. Consistent with previous studies[14,17] on supplement use and exercise, the majority of users in the present study also engaged in vigorous exercise. This finding suggests a possible correlation between physical activity and supplement usage.

According to the ADA position paper on nutrient supplementation, supplements can be used to fill gaps in certain nutrients that are not achieved through diet alone, but should not be taken as a replacement for a wholesome diet[2]. How much or little dietary supplements can improve someone's nutritional status depends largely on that person's intake of nutrients from foods. Previous reports have indicated that supplement users tend to have healthier diets that include more fruit and vegetables than non-users[6,7]. In the present study, there were greater differences in the total nutrient intake of male non-users and users (diet + supplements) than

females. This may be due in part because male students may be consuming more food in general than females. The fact that females supplemented themselves with iron *did* improve their intake, bringing most users above the RDA. Vitamin D intakes in females also improved with supplement use, but half of users still did not meet the RDA. The average calcium intake of users increased to greater than 1300mg after supplementing. Compared to the average intake of a non-user of 891 mg/day, users may be including calcium-rich foods in their diets in addition to calcium supplementation. There were significant differences in vitamin C intake between non-users and users ($p < 0.05$, 120 mg vs. 182 mg), and the contribution of vitamin C supplements increased the average user's intake from 127 mg to 182 mg. Though the percentage of students with vitamin C below the RDA was only 16% even in non-users, nationally vitamin C is still a nutrient 31% of people don't get enough of[5]. Despite the fact that 66% of male students were taking protein supplements, there was very small difference in average protein intake in supplement users over the course of the month. Since only half of the protein supplement users took it daily and one-third took protein once or twice a month, the contribution of supplemental protein to total intake averaged over a month was very small (146g vs. 142g). Furthermore, male supplement users had a higher average intake of protein from dietary sources than non-users. Since no male subjects were taking fiber supplements, and the fiber intake of users averaged 38g compared to 23g for non-users, it stands to reason that male users are eating more fiber-rich fruits, vegetables or whole grains than non-users. Though no females were put over the UL by iron supplementation, one third of male users had intakes greater than 45 mg/day. Iron-fortified foods such as cereals were not counted as a dietary supplement, and excess consumption of these foods may put one over the UL.

Data from NHANES 2001-2002[5] show that the three nutrients most Americans are lacking in their diets are vitamin E (93%), magnesium (56%) and vitamin A (44%). Compared

to national data, UConn students fare somewhat better. All of female and most of male non-users have intakes below the DRI for α-tocopherol, but 25% of female and 22% of male supplement users are below the RDA. Magnesium intakes of supplement users is markedly higher ($p < 0.05$) in both males and females than non-users, but still 25% of female and 33% of male users do not meet the DRI for this mineral. As for vitamin A status, more female users are meeting the RDA for this vitamin than male users. By and large, the main nutrients of concern in the UConn student population are fiber, vitamin D, vitamin E, calcium, magnesium, potassium and iron (in females only). The majority of male and female students are deficient in these nutrients unless they are taking a dietary supplement.

There have been very few studies detailing supplement usage in college students[19-22], and most of these studies are either 10 years outdated or only examine NVNM supplement usage in certain groups of students. This study had a few significant strengths, including studying the usage of any dietary supplement instead of limiting the study to one type of supplement, and the usage of a 30-day DR as opposed to a 24 hour DR. Using DR over a longer period of time gives a more accurate representation of usual intake than a one or two day DR. The main limitation of this study was the small sample size of 44 students, the exclusion of 16 students who dropped out, and the uneven proportion of male and female students. The study sample may not be entirely representative of all the students at UConn, but nevertheless the data provide valuable insight into the types of supplements they are using. The study was observational, not a cross-sectional placebo controlled study, so no cause and effect relationships could be inferred between supplement usage and nutrient adequacy. Finally, the students were not asked *why* they took the supplements they chose, so the exact reason for taking dietary supplements could not be determined.

## 6. Conclusions and Future Study Direction

About 38% of students in this study were taking at least one type of dietary supplement during the study period, consistent with the findings from previous studies[16,17]. About an equal proportion of males and females were taking supplements. The three most common dietary supplements taken by college students include multivitamins, protein, and vitamin C. Though taking dietary supplements *does* appear to boost certain micronutrient intakes, it does not substitute for a balanced diet. Fiber, vitamin D, vitamin E, calcium, magnesium, potassium, and iron (females only) were the main nutrients of concern in the study population. Future studies on this subject should entail a much larger population and address nutrient deficiencies commonly seen in college age students. These data underscore the need for nutrition education in college students, particularly on taking dietary supplements.

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Table 1. Characteristics of all study subjects by dietary supplement usage (n = 44)

| | Supplement Users (n = 17) | Non-users (n = 27) |
|---|---|---|
| **Gender** | | |
| **Male %** | 53 | 30 |
| **Female %** | 47 | 60 |
| **Age** | 47 | |
| **<19 years %** | 18 | 33 |
| **≥ 19 years %** | 82 | 66 |
| **Ethnicity** | | |
| **Caucasian %** | 94 | 66 |
| **African American %** | 6 | 3 |
| **Asian %** | 0 | 18 |
| **Hispanic %** | 0 | 11 |
| **BMI(kg/m$^2$)** | | |
| **Underweight(<18.5) %** | 0 | 7 |
| **Normal(18.5-24.9) %** | 76 | 78 |
| **Overweight(25.0-29.9) %** | 18 | 11 |
| **Obese(>30.0) %** | 6 | 4 |
| **Dietary Restriction** | | |
| % Yes | 29 | 22 |
| % No | 71 | 78 |
| **Pressured to be a certain weight** | | |
| % Yes | 29 | 56 |
| % No | 71 | 44 |
| **Skipped meals to lose weight** | | |
| Yes | 12 | 22 |
| No | 88 | 78 |
| **Afraid of weight gain (1-5 scale, 1=least, 5=most) %** | | |
| 1 | 35 | 26 |
| 2 | 35 | 44 |
| 3 | 18 | 22 |
| 4 | 0 | 0 |
| 5 | 12 | 7 |
| **Engaged in Moderate Activity** | | |
| % Yes | 88 | 93 |
| %No | 12 | 7 |
| **Engaged in Vigorous Activity** | | |
| % Yes | 94 | 74 |
| % No | 6 | 26 |

**Table 2. Description of supplements used by college students (n = 44)**

| Supplement Type | Total female subjects (n=27) | Total male subjects (n=17) |
|---|---|---|
| **Users %** | **n=8; 30%** | **n=9; 53%** |
| Multivitamin % | 75 | 44 |
| Protein supplement % | 13 | 66 |
| Amino Acid % | 0 | 22 |
| Fiber % | 13 | 0 |
| Soy protein % | 0 | 11 |
| B-complex or B-vitamin % | 25 | 22 |
| Vitamin C % | 38 | 33 |
| Vitamin D % | 13 | 11 |
| Iron % | 38 | 11 |
| Calcium % | 25 | 0 |
| Zinc % | 13 | 11 |
| Melatonin % | 0 | 11 |
| Quercetin % | 0 | 11 |
| Herbal Complex % | 0 | 11 |
| Fish Oils % | 0 | 22 |
| Caffeine % | 0 | 22 |
| Green Tea % | 0 | 22 |

[a] subjects may take multiple supplements of several different types.

**Table 3. Frequency of use of selected dietary supplements (n = 17)[a]**

| | Total # users per month | 1-2x/month % | 1x/week % | 2-3x/week % | 4-6x/week % | % of total uses (out of 52) |
|---|---|---|---|---|---|---|
| Multivitamin | 10 times | 30 | 10 | 10 | 50 | 18 |
| Protein | 14 times | 14 | 36 | 21 | 28 | 25 |
| Individual B-vitamins and B-complex | 4 times | 0 | 100 | 0 | 0 | 7 |
| Individual vitamins (including Zn, C, D, Fe, Ca) | 18 times | 22 | 39 | 11 | 28 | 32 |
| Other NVNM | 10 times | 20 | 30 | 10 | 40 | 18 |
| Totals | 52 times | | | | | |

[a]some users might use more than one supplement per month, at different frequencies.

Table 4. Comparison of average nutrient intakes of female college students by dietary supplementation[a]

| Nutrient | DRI[b], AI[c] or UL[d] | Supplement Users | | | Non-users | |
|---|---|---|---|---|---|---|
| | | Diet + supplements (n = 8) | Diet only (n = 8) | | Diet only (n = 19) | |
| | | Mean ± SD | Mean ± SD | P-value[e] | Mean ± SD | P-value[f] |
| **Protein (g)** | | 79±21 | 79±19 | 0.945 | 72±14 | 0.281 |
| **Fiber (g)** | | 24±7 | 24±7 | 0.923 | 20±8 | 0.277 |
| *% under AI* | 25g (F) | 63 | 63 | | 79 | |
| **Vitamin A (µg RAE)** | | 1308±532 | 1045±453 | 0.306 | 817±295 | p<0.05 |
| *% under RDA* | 700µg (F) | 13 | 25 | | 32 | |
| **β-carotene (µg)** | | 5184±2060 | 5104±2052 | 0.939 | 3857±3228 | 0.296 |
| **Lutein + zeaxanthin (µg)** | | 2666±1023 | 2603±1085 | 0.907 | 2689±2652 | 0.981 |
| **Lycopene (µg)** | | 4889±3174 | 4830±3181 | 0.971 | 5442±2926 | 0.665 |
| **Vitamin C (mg)** | | 182±67 | 127±36 | 0.061 | 120±51 | p<0.05 |
| *% under RDA* | 18y: 65mg (F) | 0 | 13 | | 16 | |
| | 19+y: 75mg (F) | | | | | |
| **Vitamin D (IU)** | | 16±10 | 5±4 | p<0.05 | 3.5±1 | p<0.05 |
| *% under AI* | 15 mg (F) | 50 | 100 | | 100 | |
| **α-tocopherol (mg)** | | 21±7 | 13±4 | p<0.05 | 9.7±2 | p<0.05 |
| | 15 mg (F) | 25 | 88 | | 100 | |
| **Calcium (mg)** | | 1343±508 | 1130±472 | 0.398 | 891±189 | p<0.05 |
| *% under RDA* | 18y:1300mg (F) | 38 | 50 | | 84 | |
| | 19+y: 1000mg (F) | | | | | |
| **Magnesium (mg)** | 18y: 360mg (F) | 384±100 | 347±82 | 0.437 | 273±79 | p<0.05 |
| | 19+y: 310mg (F) | 25 | 25 | | 79 | |
| **Potassium (mg)** | | 2956±647 | 2956±647 | 1.000 | 2495±748 | 0.141 |
| *% under RDA* | 4700mg (F) | 100 | 100 | | 100 | |
| **Iron (mg)** | | 25±7 | 18±6 | p<0.05 | 16.5±3 | p<0.05 |
| *% under RDA* | 18y: 15mg (F) | 0 | 38 | | 68 | |
| | 19+y: 18mg (F) | | | | | |
| *% over UL* | 45mg (F) | 0 | 0 | | 0 | |
| **Folate (mg)** | | 665±195 | 520±129 | 0.103 | 477±117 | p<0.05 |
| *% under RDA* | 400mg (F) | 0 | 0 | | 32 | |
| | 18y: 800mg, | | | | | |
| *% over UL* | 19+y:1000mg | 13 | 13 | | 0 | |
| **Selenium (µg)** | 55µg (F) | 128±55 | 110±25 | 0.409 | 105±22 | 0.129 |
| **Total Polyphenols (mg)** | | 178±99 | 178±99 | 1.000 | 226±216 | 0.552 |

[a]Comparing supplement users and non-users nutrient intake from food and supplements

[b]DRI=Dietary Reference Intake, 2010 guidelines

[c]AI=Adequate Intake

[d]UL=Tolerable Upper Intake Level

[e]Compares users intake before and after nutrients from dietary supplements were calculated.

[f]Compares non-users intake from food only with supplement users intake from diet plus supplements.

Table 5. Comparison of average nutrient intakes of male college students by dietary supplementation[a]

| Nutrient | DRI[b], AI[c] or UL[d] | Supplement Users | | | Non-users | |
|---|---|---|---|---|---|---|
| | | Diet + supplements (n = 9) | Diet only (n = 9) | | Diet only (n = 9) | |
| | | Mean ± SD | Mean ± SD | P-value[e] | Mean ± SD | P-value[f] |
| **Protein (g)** | | 146±62 | 142±61 | 0.867 | 111±37 | 0.178 |
| **Fiber (g)** | | 38±19 | 38±19 | 0.981 | 23±9 | 0.058 |
| *% under AI* | 38g (M) | 55 | 55 | | 100 | |
| **Vitamin A (µg RAE)** | | 1126±522 | 1006±510 | 0.628 | 1233±661 | 0.715 |
| *% under RDA* | 900µg (M) | 33 | 44 | | 38 | |
| **β-carotene (µg)** | | 4829±3812 | 4787±3852 | 0.982 | 4531±2820 | 0.858 |
| **Lutein + zeaxanthin (µg)** | | 3377±2153 | 3045±2344 | 0.758 | 2590±1723 | 0.422 |
| **Lycopene (µg)** | | 12289±13241 | 12181±13284 | 0.999 | 5042±3619 | 0.155 |
| **Vitamin C (mg)** | | 179±80 | 146±76 | 0.378 | 159±68 | 0.587 |
| *% under RDA* | 18y: 75mg (M)<br>19+y:90mg (M) | 22 | 33 | | 0 | |
| **Vitamin D (IU)** | | 11±10 | 8±5 | 0.336 | 7±5 | 0.323 |
| *% under AI* | 15 mg (M) | 78 | 88 | | 88 | |
| **α-tocopherol (mg)** | | 33±23 | 27±18 | 0.559 | 14±8 | p<0.05 |
| | 15 mg (M) | 22 | 33 | | 75 | |
| **Calcium (mg)** | | 1383±647 | 1301±633 | 0.790 | 1201±481 | 0.525 |
| *% under RDA* | 18y:1300mg (M)<br>19+y: 1000mg (M) | 33 | 33 | | 50 | |
| **Magnesium (mg)** | 18y: 410mg (M) | 558±209 | 543±209 | 0.879 | 351±115 | p<0.05 |
| | 19+y: 400mg (M) | 33 | 33 | | 63 | |
| **Potassium (mg)** | | 4187±1415 | 4147±1415 | 0.953 | 3301±1049 | 0.167 |
| *% under RDA* | 4700mg (M) | 77 | 77 | | 88 | |
| **Iron (mg)** | | 39±29 | 31±19 | 0.504 | 23±5 | 0.147 |
| *% under RDA* | 18y: 11mg (M)<br>19y: 8mg (M) | 0 | 0 | | 0 | |
| *% over UL* | 45mg (M) | 33 | 33 | | 0 | |
| **Folate (mg)** | | 1017±579 | 954±612 | 0.825 | 650±223 | 0.113 |
| *% under RDA* | 400mg (M) | 0 | 0 | | 0 | |
| *% over UL* | 18y: 800mg, 19+y:1000mg | 33 | 33 | | 13 | |
| **Selenium (µg)** | 55µg (M) | 185±57 | 179±55 | 0.813 | 157±58 | 0.328 |
| **Total Polyphenols (mg)** | | 674±547 | 526±385 | 0.544 | 265±186 | 0.063 |

[a]Comparing supplement users and non-users nutrient intake from food and supplements

[b]DRI=Dietary Reference Intake, 2010
guidelines

[c]AI=Adequate
Intake

[d]UL=Tolerable Upper Intake Level

[e]Comparing supplement users intake from diet and supplements with non-users intake from food sources

[f]Compares non-users intake from food only with supplement users intake from food plus supplements.

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