PREVALENCE AND PREDICTORS OF HIGHER-RISK SUPPLEMENT USE AMONG COLLEGIATE ATHLETES

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ABSTRACT

Sassone, J., Muster, M., and Barrack, MT. Prevalence and predictors of higher-risk supplement use among National Collegiate Athletic Association Division I athletes. J Strength Cond Res XX(X): 000–000, 2018—This study aimed to identify the prevalence and predictors associated with the use of higher-risk dietary supplements, defined as supplements containing herbal ingredients, caffeine, or those classified for weight loss, muscle-building, or as a preworkout supplement, among 557 National Collegiate Athletic Association Division I male and female collegiate athletes. Although 252 (45.2%) athletes reported the use of a dietary supplement on ≥2 days per week over the past year, 46 (8.3%) athletes met criteria for higher-risk supplement use. Twenty (3.6%) athletes reported the use of herbal, 1 (0.2%) caffeinated, 5 (0.9%) weight loss, 28 (5.0%) preworkout, and 1 (0.2%) muscle-building supplements. Body mass index status (BMI ≥30 kg·m−2), sport-type (sports using the phosphocreatine energy system), and college year (≥4th year) were associated with the use of preworkout, muscle-building, or herbal supplements. A multiple regression analysis identified predictors of higher-risk supplement use including the number of dietary supplements used in the past year (odds ratio [OR] = 2.1, 95% confidence interval [CI] = 1.7–2.7, p < 0.001), the reported motivation of taking dietary supplements to gain muscle and lose body fat (OR = 3.5, 95% CI = 1.1–11.7, p = 0.04), and the motivation to increase athletic endurance (OR = 3.5, 95% CI = 4.0, 95% CI = 1.6–9.9, p < 0.005). These factors may be considered as a part of a screening process to evaluate athletes with an increased risk of higher-risk supplement use and potential consequences to health or eligibility status.

KEY WORDS NCAA, eligibility, health

INTRODUCTION

Previous investigations indicate that a significant proportion of athletes use dietary supplements, with a recent meta-analysis reporting an overall prevalence estimate of 61% (27). However, rates of use for collegiate athletes, specifically, may be higher with estimates reported up to 88% (8,17,24). Several factors have been linked to athletes’ use of dietary supplements, including competing in a power or sprint (vs. mid-distance or long-distance) track and field event, and involvement in a sport with weight categories (16,21,29,45). Dietary supplement use may be associated with the competitiveness of a sport, as higher estimates of supplement use have been reported among elite compared with nonelite athletes or those competing on a national team (21,27). Supplement use may also differ by sex, with some investigations reporting a higher use of protein or amino acid supplements, creatine, and weight gain supplements among male athletes and a higher use of calcium, iron, multivitamin, and weight loss supplements among female athletes (15,17,38). These findings represent a preliminary understanding of supplement use among collegiate athletes and factors related to their use (27).

According to the 1994 Dietary Supplement Health and Education Act (DSHEA), supplement manufacturers are not required to provide evidence that their supplement is safe, or that their supplement label is accurate, before sale (34). The Food and Drug Administration (FDA) can take action against a supplement product after it is marketed and shown to be adulterated or misbranded. As a result of this limited regulation, due to intentional inclusion, or as a result of poor manufacturing procedures, dietary supplements may contain banned substances, pharmaceutical agents, contaminants, or other ingredients posing health risks (19,40). Furthermore, the label may contain misleading claims or misrepresent the amount of a listed ingredient contained in the product (11,18,32).

A recent investigation by Geller et al. reported that more than 20,000 emergency department visits and 2,000 hospital admissions, annually, are attributed to dietary supplement use. Nearly 30% of patients affected are young adults, such as collegiate athletes, aged 20–34 years (19). Products linked to...
a significant proportion of visits included those with herbal ingredients and those marketed for weight loss or energy (19). Previous research also provides evidence of herbal supplements containing heavy metals, and some ingredients, such as yohimbe, bitter orange, comfrey, and kava, promoting hepatotoxicity, cardiovascular effects, or drug interactions (9,40,47). In the past, weight loss supplements have been banned for containing dangerous ingredients, such as ephedra, and the FDA reported weight loss supplements containing undisclosed pharmaceutical agents (4,39). Furthermore, potentially harmful ingredients have been found in weight loss supplements, including the drug, 2, 4 dinitrophenol (37).

Preworkout supplements and products marketed for muscle building are also linked to adverse health events. Some preworkout products have contained ingredients, such as dimethylamylamine (DMAA) or methylhexaneamine, which has been shown to elicit effects such as increased blood pressure, shortening of breath, chest tightness, and heat attack (19,26,43). The banned stimulant dimethylbutylamine was also found in 12 of 14 tested preworkout products (5,11). A recent report evaluating muscle-building supplements found an association between their use and an increased incidence of testicular cancer (31). A study of 37 prohormone muscle-building supplements found that 14 were contaminated with either testosterone or the banned steroid nandrolone (7). Furthermore, in 2009, the FDA issued a warning against body-building supplements because of potential risks of liver and kidney damage (46).

Caffeine is prohibited by the National Collegiate Athletic Association (NCAA) when taken in an amount yielding a urine caffeine level at or above 15 μg·ml⁻¹. However, in the United States, the amount of caffeine contained in dietary supplements is unregulated, and the labeled amount may underrepresent or overrepresent the actual caffeine dose per serving (22,23). Adverse effects of caffeine typically manifest with acute ingestion greater than 200 mg with effects including insomnia, nervousness, headache, tachycardia, arrhythmia, elevated heart rate, elevated blood pressure, nausea, heart attack, and death (6,10,12,14,23).

Therefore, sports supplements containing herbal ingredients, caffeine, or those classified for weight loss, muscle-building, or as a preworkout supplement, in particular, may pose an elevated risk of adverse health events (1,19,22). Furthermore, as athletic organizations, such as the NCAA, test collegiate athletes for banned substances, athletes may inadvertently consume a forbidden ingredient if undisclosed on the supplement label, which may affect their eligibility status (2,23,25,35,36). Potential risks to an
athlete’s eligibility status has been substantiated by reports of supplements that were chemically analyzed containing substances such as prohormones, steroids, or stimulants that were not listed on the product label (20). Previous research involving chemical analyses of individuals’ urine after consuming dietary supplements also supports the potential for a positive drug test after use of a dietary supplement (48). Furthermore, previous investigations report herbal supplements containing ingredients banned by the NCAA, such as bitter orange (36), while weight loss supplements may contain banned ingredients such as amines, diuretics, BMPEA, and β2-agonists (12,20,36).

Although dietary supplement use may affect athletes’ health and their eligibility status, there is a limited body of literature addressing the proportion of collegiate athletes taking supplements associated with a higher level of risk, as well as factors predicting their use (1,19,22,27,42). Therefore, this study aimed to identify the prevalence and factors associated with the use of these higher-risk supplements (i.e., those containing herbal ingredients, caffeine, those classified for weight loss, muscle-building, or as a preworkout supplement) among NCAA Division I athletes.

**METHODS**

**Experimental Approach to the Problem**

This cross-sectional study administered a 13-item survey to evaluate higher-risk dietary supplement use among collegiate athletes participating in 10 sports at 2 NCAA Division 1 schools in southern California.

**Subjects**

Participants were male and female NCAA Division 1 athletes aged 18–26 years. Participation in this study was voluntary. A total of 596 athletes (316 male athletes and 280 female athletes) consented to participate and submitted a study survey (84.5% response rate), while 557 athletes submitted surveys with complete data regarding supplement use (Figure 1). Athlete participants competed in baseball, softball, basketball, volleyball, tennis, golf, water polo, soccer, cross-country, or track and field. The study was approved by the institutional review board of California State University. Written consent was not required by the review board because the surveys were anonymous and the nature of the protocol was low risk.

**Procedures**

**Data Collection.** Survey administration occurred during a 10- to 15-minute session at annual team compliance meeting. Athletes were provided with written information regarding the study’s purpose, time commitment, procedures, and the potential future benefits of the study and related findings. Those consenting to participate completed and submitted a written study survey during the meeting session. Athletes were not asked to provide any identifying information on the study survey, yielding confidential and anonymous responses.

**Study Survey.** The 13-item survey was designed by the authors and adapted from previous surveys (13,17,30,44). The survey included 8 multiple choice and 5 short-answer questions that inquired about athletes’ primary sport, height, body mass, dietary supplement use, motivations for using...
dietary supplements, sources of information regarding supplement use, and perceived knowledge regarding the health, safety, and NCAA regulations regarding dietary supplement use. In the survey, dietary supplements were defined as “products taken to supplement the diet and consumed in the form of a tablet, capsule, softgel, gelcap, liquid, or powder.” For further clarification, examples were provided in the survey, “Examples of dietary supplement ingredients include vitamins, minerals, essential amino acids, creatine, protein powders, fish oil or other fatty acids, herbal ingredients (such as ginseng, ginkgo biloba, echinacea, etc.), or other natural substances (such as quercetin, melatonin, glucosamine, coenzyme Q10, etc.).” Athletes were asked to provide the brand and name of all dietary supplement products taken on at least 2 days per week during the past year. Athletes were not asked to report the dosage of supplements consumed.

**Higher-Risk Dietary Supplements.** Higher-risk dietary supplements were defined as those containing herbal ingredients, caffeine, or those classified for weight loss, muscle-building, or as a preworkout supplement. The definitions of each higher-risk supplement type included the following: herbal—containing herbal ingredients, not marketed as a weight loss, preworkout, or muscle-building supplement; weight loss—supplements either labeled for “weight loss” or marketed for the primary purpose of losing weight; caffeinated—supplements containing caffeine, not otherwise marketed as a preworkout, muscle-building, or weight loss supplement; preworkout—supplements either labeled as “preworkout” or marketed for the purpose of increasing energy and performance and taken before exercise; and muscle-building—those either marketed as “muscle-building” or taken for the primary purpose of gaining muscle mass.

These supplements were considered higher-risk because of their potential to contain NCAA banned ingredients or pose an increased risk to the health and safety of collegiate athletes. Supplement categorization was mutually exclusive, with each supplement grouped into 1 category.

**Athlete Classifications.** Athlete participants were stratified by sports-type based on the energy system(s) used in their primary sport. The 3 energy system categories, adapted from criteria reported by Froiland et al. (17), include (a) sports that predominantly use the phosphocreatine (PCr) system (golf, baseball, and softball, n = 157), (b) sports that use both the...
PCr system and anaerobic glycolysis (AG) energy systems (PCr/AG) (basketball, volleyball, tennis, sprint and field events in track and field, and water polo, *n* = 313) and (c) sports that use the PCr system, anaerobic system, and aerobic system (PCr/AG/oxidative phosphorylation) (soccer, middle distance/distance track and field events, and cross-country, *n* = 85).

Athletes were also grouped by sex (male, *n* = 299; female, *n* = 258), body mass index (BMI) status (BMI ≥ 30 kg·m⁻², *n* = 511; BMI < 30 kg·m⁻², *n* = 27), and year in college (1st, 2nd, and 3rd college year, *n* = 410; 4th or later college year, *n* = 146).

### Statistical Analyses
Continuous variables are represented as mean ± SEM and dichotomous variables as frequencies (%). Independent *t*-tests evaluated differences in height, body mass, and BMI status between male and female participants. Chi-square analyses evaluated group differences for dichotomous variables (i.e., supplement use based on BMI status, sport-type, college year, and sex). Univariate and multivariate logistic regression analyses, yielding odds ratio (OR) (95% confidence interval [CI]), evaluated predictors of higher-risk supplement use, including BMI ≥ 30 kg·m⁻², ≥4th college year, use of ≥3 supplements, and 10 motivations for supplement use. The multivariate regression analysis evaluated the degree to which each of the 4 variables including, ≥4th college year, number of supplements used, and motivations for supplement use (increased athletic performance and increased muscle mass and reduce body fat) contributed to the prediction of higher-risk supplement use. The model was adjusted for sex, BMI status, and sports-type. All analyses were performed using SPSS software, with an alpha level of 0.05.

### Results
Table 1 outlines the descriptive characteristics of the 557 athletes submitting complete data regarding dietary supplement use. Body mass index fell between 18.5 and 29.9 kg·m⁻² for a majority of the sample (93.3%) and over 3 quarters (84.1%) of the athletes participated in a sport predominantly using the PCr or the PCr/AG energy systems (Table 1).

Of the 557 respondents, 252 (45.2%) reported the use of ≥1 dietary supplements ≥2 days per week over the past year. Athletes with the use of supplements reported taking

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### Table 3. Univariate logistic regression analyses evaluating individual predictors of higher-risk supplement use.*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Higher-risk supplement use†, n (%)</th>
<th>Odds ratio (95% CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI ≥ 30 kg·m⁻²</td>
<td>6 (22.2)</td>
<td>3.5 (1.3–9.1)</td>
<td>0.01</td>
</tr>
<tr>
<td>≥4th college year</td>
<td>20 (13.7)</td>
<td>2.3 (1.3–4.3)</td>
<td>0.01</td>
</tr>
<tr>
<td>Use of ≥3 supplements</td>
<td>30 (65.2)</td>
<td>5.0 (2.5, 9.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Motivations for supplement use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improve health and nutrient intake</td>
<td>26 (14.1)</td>
<td>2.8 (1.5–5.2)</td>
<td>0.001</td>
</tr>
<tr>
<td>Weight loss</td>
<td>9 (25.0)</td>
<td>4.2 (1.9–9.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Increase athletic endurance</td>
<td>18 (14.9)</td>
<td>2.5 (1.3–4.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Increase strength/power</td>
<td>17 (24.3)</td>
<td>4.9 (2.5–9.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Improve recovery</td>
<td>25 (16.8)</td>
<td>3.6 (1.9–6.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Increase muscle mass</td>
<td>23 (19.2)</td>
<td>4.1 (2.2–7.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Increase muscle mass and reduce body fat</td>
<td>24 (18.6)</td>
<td>4.1 (2.2–7.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Reduce body fat</td>
<td>17 (40.5)</td>
<td>11.1 (5.4–22.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Reduce injury, disease, or illness</td>
<td>16 (17.2)</td>
<td>2.9 (1.5–5.6)</td>
<td>0.001</td>
</tr>
<tr>
<td>Increase muscle mass and reduce body fat</td>
<td>14 (60.9)</td>
<td>23.8 (9.6–59.2)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*CI = confidence interval; BMI = body mass index.†Reported as frequency n(%).

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### Table 4. Multiple logistic regression model† with predictors of higher-risk supplement use.*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds ratio (95% CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status as ≥4th year college student</td>
<td>2.1 (0.9–4.5)</td>
<td>0.07</td>
</tr>
<tr>
<td>No. of supplements</td>
<td>2.1 (1.7–2.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Motivations for supplement use</td>
<td>4.0 (1.6–9.9)</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>Increase athletic endurance</td>
<td>3.5 (1.1–11.7)</td>
<td>0.04</td>
</tr>
</tbody>
</table>

*CI = confidence interval.†Adjusted for sex, BMI status, and sports-type.
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an average of 2.3 ± 0.1 supplements ≥2 days per week over the past year. Among the sample, 46 athletes (8.3%) met criteria for using ≥1 higher-risk supplements (Figure 1). The number of higher-risk supplements taken by those reporting the use of higher-risk supplements ranged from 1 to 5 (mean 1.4 ± 0.1 supplements). Of the 46 higher-risk supplement users, 35 took 1 (6.3%) and 11 (2.0%) reported the use of 2–5 higher-risk supplements ≥2 days per week over the past year. The higher-risk subcategories taken most frequently included herbal (3.6%) and preworkout (5.0%) supplements (Figure 1).

Chi-square tests found no significant differences in the frequency of higher-risk supplement use based on sex or sport-type; however, a higher frequency of male compared with female athletes (X² = 5.4) and athletes participating in sports using the PCr compared with other energy systems (X² = 9.7) reported the use of preworkout supplements (Table 2). Athletes with a BMI ≥30 kg·m⁻² compared with <30 kg·m⁻² reported a higher overall use of higher-risk supplements (X² = 7.1), a higher use of preworkout supplements (X² = 10.9), and muscle-building supplements (X² = 19.0) (Table 2). Athletes in their 4th or later year of college (compared with the 1st, 2nd, or 3rd year) reported a higher frequency of higher-risk supplement use (X² = 7.6) and use of herbal (X² = 3.7) and preworkout (X² = 8.5) supplements (Table 2).

Table 3 represents the univariate logistic regression analyses evaluating single predictors of higher-risk supplement use in the athlete sample. Factors significantly contributing to the prediction of higher-risk supplement use included BMI ≥30 kg·m⁻² (vs. <30 kg·m⁻²), status as a 4th year (or later) college student (compared with 1st, 2nd, or 3rd year students), use of ≥3 dietary supplements (compared with the use of <3 dietary supplements on ≥2 times per week over the past year), and 10 motivations for taking dietary supplements (Table 3). The reported use of dietary supplements for the purpose of reducing body fat emerged as the strongest single predictor of higher-risk supplement use (OR = 11.1, 95% CI = 5.4, 22.9) (Table 3); however, the OR for the concurrent reporting of using dietary supplements to gain muscle mass and lose body fat was significantly higher than either factor alone (Table 3).

The multiple regression model, presented in Table 4, adjusting for sex, sport-type, and BMI status indicated that the number of supplements athletes took (≥2 times per week over the past year), the reported motivations to increase athletic endurance, and the motivation to both increase muscle mass and reduce body fat emerged as concurrent, independent predictors of higher-risk supplement use (Table 4).

**Discussion**

To the best of our knowledge, this is the first study evaluating the prevalence and predictors associated with the use of higher-risk dietary supplements, defined as those containing herbal ingredients, caffeine, or classified for weight loss, muscle-building, or as a preworkout supplement, among a large sample of collegiate athletes. While 45.2% of the sample reported the use of dietary supplements on at least 2 days per week over the past year, 8.3% reported the use of one or more higher-risk supplements. Variables that emerged as significant in the multiple regression model included the reported motivation to take supplements for the purpose of losing body fat and gaining muscle mass, the motivation of increasing athletic endurance, and the number of dietary supplements consumed (≥2 days per week over the past year). These findings shed light on potential factors that could be addressed when screening athletes for higher-risk supplement use for the purpose of lessening potential consequences to health and eligibility status.

The 45.2% prevalence of total supplement use in the current sample is less than estimates listed from previous investigations. Froiland et al. (n = 207), Hoyte et al. (n = 462), and Burns et al. (n = 236) reported prevalence estimates of supplement use among U.S. collegiate athletes of 61, 85.9, and 88%, respectively (8,17,24). These differences may be due to variances in the definition of dietary supplement use, as the prevalence for the current study specifically represents use based on a defined frequency and duration (i.e., ≥2 days per week over the past year). Thus, the prevalence of taking supplements in this study represents regular or habitual compared with experimental or short-term use, which may represent a greater association with potential risks due to prolonged exposure.

Although no other study has reported on the overall prevalence of higher-risk supplement use, as a whole, in collegiate athletes, Froiland et al. (17) reported on the prevalence of taking herbal, weight loss, and muscle-building supplements among a collegiate sample. They found a higher reported use of each, 26 vs. 3.6%; 48 vs. 0.9%; and 7.4 vs. 0.2%, for herbal, weight loss, and muscle-building supplements, compared with the current sample, respectively (17). Furthermore, upon the evaluation of junior college athletes, Munoz (33) reported a higher prevalence of caffeine/stimulant use compared with the current study (11.9 vs. 0.2%, respectively. The current study may underrepresent the use of caffeine-containing supplements because of the fact that many preworkout supplements contain caffeine, and these were not categorized in the caffeine group (as groups were mutually exclusive). Furthermore, the current study only addressed caffeine exposure because of supplement use rather than exposure from coffee or energy drinks. Also, the current study did not include sports teams with a higher potential use of higher-risk supplements such as football. Future research is recommended to further evaluate the prevalence of higher-risk supplement use, and the respective higher-risk supplement categories, among a sample of collegiate athletes representing a variety of sports.

The chi-square analysis indicated no significant difference in higher-risk supplement use between male compared with
female athletes, which is consistent with previous investigations (27,28). However, those classified with BMI $\geq 30$ kg·m$^{-2}$ and those with status of as 4th year (or later) college student reported a higher frequency of higher-risk supplement use. Body mass index and college year status also emerged as significant individual predictors of higher-risk supplement use in the univariate logistic regression analyses. Body mass index, however, did not emerge significant in the multiple regression model, while college year status trended toward significance. Other studies suggest a more frequent use of dietary supplements among more elite and experienced athletes (21,28), which may be related to a higher level of pressure to perform or a greater reliance on ergogenic aids as an athlete ages and/or becomes more senior in their sport.

Other notable variables associated with higher-risk supplement use included 10 self-reported motivations, with the strongest motivations also significant in the multiple regression model, including use of supplements to concurrently lose body fat and increase muscle mass. Furthermore, the number of supplements athletes reported taking (at least twice per week over the past year) positively predicted the likelihood of taking a higher-risk supplement in the univariate and multivariate model. These are novel findings, and future research is recommended to further elucidate the relationships between these motivations for taking dietary supplements, the number of dietary supplements taken, and higher-risk supplement use. However, if these factors also emerge as significant in future investigations, surveying athletes about their motivations for taking dietary supplements and tracking the number of supplements athlete take on a regular basis, in addition to considering other potential key factors, would serve as an efficient method of identifying collegiate athletes with a greater potential likelihood of taking a supplements that may expose them to an elevated risk of negative effects to health and/or eligibility status.

While, overall, higher-risk supplement use did not differ based on sex, our findings indicated that a higher proportion of male compared with female athletes reported the use of preworkout supplements. In addition, athletes with a BMI $\geq 30$ kg·m$^{-2}$ (vs. $<30$ kg·m$^{-2}$), those participating in sports primarily using the PCr energy system, and those with status as a 4th year (or later) college student also reported a significantly higher frequency of using preworkout supplements. Previous research has reported a higher use of energy supplements, which contain ingredients similar to preworkout supplements, among male collegiate athletes (17). As preworkout supplements may contain unregulated levels of caffeine and stimulants such as DMAA, which may pose moderate to severe health threats to an athlete competitor and affect eligibility status, it is important to identify subgroups of athletes with an increased risk of using this supplement type.

Limitations of this study include the self-report nature of the study survey. Team coaches were present while athletes completed the survey, which may have limited athletes' willingness to provide complete disclosure regarding higher-risk supplement use. As a result, the findings may underestimate the amount and frequency of higher-risk supplements taken by collegiate athletes. Furthermore, the dietary supplement patterns of use in collegiate athletes in southern California may not reflect behaviors of all college athletes in the United States.

**PRACTICAL APPLICATIONS**

The findings from this study identify subgroups of collegiate athletes with a higher potential likelihood of taking supplements that may negatively affect their health and/or eligibility status. This may aid in targeting efforts to educate collegiate athletes on weighing the potential risks and benefits of dietary supplement use and guiding their decision-making process. Findings from this study also underscore the need for practitioners to assess collegiate athletes’ supplement use and remain informed about policies affecting the regulation of dietary supplements as well as current ingredients or products posing increased risk.

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