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Collegiate Student-Athletes' Use and Knowledge of Third-Party-Tested Nutritional Supplements: An Exploratory Study

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Context: Nutritional supplement use in athletes is common, accompanied by potential doping risk.

Objective: To determine athletes' nutritional supplement and third-party-tested (TPT) supplement use, supplement knowledge, and factors influencing their behavior.

Design: Cross-sectional study.

Setting: National Collegiate Athletic Association Division I athletic departments.

Patients or Other Participants: Student-athletes (n = 410, 53% female, age = 21.4 ± 1.6 years).

Main Outcome Measure(s): Survey questions addressed topics including nutritional supplement knowledge and use, TPT supplement knowledge and use, and logo recognition, and data were stratified for sex differences.

Results: Athletes (91%) reported the use of supplements, but the total number of supplements used was lower in female (median = 7; interquartile range, 4–11) than in male (median = 9; interquartile range, 4–12) athletes, with $U = 17\,960$ and $P = .01$. A total of 48% (n = 191, out of 402 responses) reported purchasing supplements outside of their athletic department, with significantly fewer female (40%, n = 84) than male (56%, n = 107) athletes reporting this behavior ($\chi^2 = 11.20$, $P < .001$). No association between TPT logo recognition and TPT use was seen ($\chi^2 = 0.238$, $P = .63$). Of all athletes using supplements, 38% (n = 140) reported "consistent TPT use," whereas female athletes (36%, n = 70) reported this less often than male athletes (41%, n = 70, $\chi^2 = 0.952$, $P < .32$). No sex differences were seen for receiving nutritional counseling (89%, $P = .37$) or low nutritional supplement knowledge (<50%, $P = .38$); however, males had 2.5 times greater odds at recognizing a TPT organization logo than females (odds ratio = 2.45; 95% CI, 1.58–3.79).

Conclusions: Most athletes use nutritional supplements. Female athletes report slightly fewer supplements than male athletes, while also less frequently purchasing them outside their athletic department, potentially explaining the lower TPT logo recognition in female athletes.

Key Words: dietary supplements, sport foods, ergogenic aids, banned substances, antidoping

Key Points

- Although most athletes report receiving nutritional education, their knowledge regarding nutritional supplements is low.
- Only one-third of athletes report consistent use of third-party-tested supplements considered to be a safe option regarding doping risk.
- Male athletes used supplementation slightly more often than female athletes (median of 9 versus 7 supplements in the last 12 months) and more often reported purchasing supplements externally.

It is common practice for collegiate athletes in the United States to incorporate dietary supplements into their daily diets to help speed up recovery after hard workouts and to improve their athletic performance.[1] Although no exact definition has been created, "food first," often interpreted as "food only," is commonly accepted as the preferred nutrition strategy for sport nutrition advice.[2,3] Best practices for nutritional supplement use or nonuse have been frequently argued in sports and, recently, suggest to push the switch from a "food only" approach to a more practical "food first, but not always food only" approach.[3] The rationale for this switch is that a "food only" approach may be impractical for athletes for several reasons, including not being able to ingest an effective dose of a substance with food products only, ease of access, and safety of consumption.[2] At the same time, most athletes already include nutritional supplements in their diet, as up to 97% of athletes report the use of nutritional supplements during their athletic career.[4]

Dietary supplementation has been defined by the International Olympic Committee as a "food, food component,

nutrient, or non-food compound that is purposefully ingested in addition to the habitually consumed diet with the aim of achieving a specific health and/or performance benefit."[3] We have previously divided nutritional supplements into 3 categories: dietary supplements, sports foods, and ergogenic (ie, performance-enhancing) supplements.[1] Dietary supplements are consumed orally and are often aimed to improve overall health by providing a remedy for deficiencies, for example, vitamin or mineral supplements.[5] In the United States, sports foods are distinguished primarily by the nutrition facts label because these foods are subject to Food and Drug Administration regulations.[1,5] Sports foods, such as sports drinks and protein or energy bars, are often classified as supplements aiming to provide a convenient macronutrient or electrolyte supplementation. Ergogenic supplements are produced and marketed with the intent to provide an advantage to athletes via enhanced performance and/or recovery.[1,5] Common examples of ergogenic aids include caffeine, creatine, and dietary nitrate. Each of these categories includes compounds that are either aimed to fill a nutritional deficiency or improve an athlete's performance.[1,4] At the same time, the incorporation of nutritional supplements, as described previously, that are not regulated by the Food and Drug Administration as a part of the daily diet increases the risk of inadvertent doping.[3]

Many competitive (inter)national sport organizations, including the National Collegiate Athletic Association (NCAA), require athletes to follow antidoping regulations to promote athlete health and safety and prevent an athlete's unfair advantage resulting from substance use.[6] The regulations and banned substances imposed by the NCAA are found on the organization's website.[7] Athletes participating in NCAA competition are subject to drug testing, and if a positive doping test is identified, the repercussions can include loss of eligibility to participate and compete.[6] Based on a meta-analysis, nearly 30% of dietary supplements examined contained substances not listed on the label, including doping-related substances.[8,9] To help mitigate the risk of testing positive for banned substances (eg, opioids or anabolic steroids), allied health professionals working with athletes and the US Anti-Doping Agency advise that athletes should not assume that a product is safe and should use nutritional supplements that have been certified by third-party testing (TPT) organizations for doping substances.[10,11] Third-party-testing programs are tightly regulated and are required to meet a list of accreditation standards created by the International Standard Organization.[12] A substantial number of TPT programs, but not all, specifically provide quality assurance testing suitable for athletes to ensure that nutritional supplements do not contain banned substances.[13–15]

Because the prevalence of supplement use in athletes is high, it is important to educate athletes on the safety of these products and what types of products are appropriate for use. It is well understood that the use of TPT supplements reduces the chance that supplements contain off-label ingredients, but it is especially important to ensure that these third-party organizations are those with athletes in mind.[12] These athlete-centric organizations test not only for off-label ingredients but also doping-related substances that may be associated with positive doping tests. A study examining the education of athletes in relation to their supplement use has been done; however, the link between education and the decision to use TPT supplements is not documented.[4] In a Dutch athlete population, it has been reported that athletes receiving dietary counseling made better informed choices toward supplement use, and, at the same time, more female athletes reported to have received dietary counseling than their male counterparts.[4] The data on sex differences for supplement use are inconclusive.[16] Differences in supplement use between sexes may originate from physiological and/or behavioral differences. For example, physiologically, females may have a higher need for certain supplements; for example, they have a higher defined iron need.[17] In addition, sex differences may also be more behaviorally driven without a clear physiological indication; for example, it has been seen that female athletes are more likely to use supplementation linked to health outcomes than performance.[18] However, there is little to no accordant data regarding the difference in TPT supplement use.

The aim of this study was to determine NCAA Division I collegiate athletes' nutritional supplement use, the portion of self-reported TPT supplements, and their knowledge of TPT products and TPT organization logos. We hypothesized that athletes who consistently use TPT products would be more likely to recognize the TPT organization logos. An exploratory aim of this study was to examine the sex differences in TPT use, and, although we hypothesized that some differences could be detected for supplement use that could be related to sex, no clear differences were expected regarding overall supplement use or TPT use.

METHODS

Research Design

This cross-sectional cohort design used an anonymous questionnaire using Qualtrics (SAP) to assess collegiate student-athletes' nutritional supplement use (including if they were purchased as TPT) as well as their knowledge of, and motivations for, using TPT products. Data were collected from 6 different NCAA Division I athletic departments from various regions in the United States between October 2022 and April 2023.

Participants

The 6 athletic departments that were selected to participate come from various conferences across the United States based on local contact and overall athletic department willingness to participate. All athletic departments submitted a letter of approval allowing the research team to contact and incentivize athletes. The 6 athletic departments included an estimated total of 3580 student-athletes, ranging from 480 to 900 student-athletes per athletic department. Respondents had to be at least 18 years of age but under the age of 35, a current member of a varsity sport at 1 of the participating athletic departments, and respond to at least 70% of the questionnaire. Excluded from the dataset for this analysis were responses that were severely incomplete (<70% of the questions). In cases of duplicate responses, the first response (identified via time stamp) was kept. The study was approved by the Arizona State University Institutional Review Board (STUDY00015034). Student-athletes read and checked informed consent before accessing the questionnaire.

Our sample size calculation was based on an estimated total of 460 000 NCAA Division I to Division III student-athletes,

using a confidence level of 95% with a margin of error of 5% and an estimated 50% of athletes using a TPT supplement.[19] This resulted in a minimum number of 384 participants needed. As oversampling reduces self-recruitment bias, we aimed to add ~10% to the original number, aiming for 420 responses.

Recruitment Procedures

Three methods of recruitment were used for this study. (1) All 6 athletic departments were sent a generalized email explaining the study's purpose, advertising the incentive, and providing a link at the bottom of the email. This email was distributed by a designated local contact in the school's athletic department. (2) Four out of 6 athletic departments chose to use, in addition to the email, a poster advertisement containing the same information as seen in the email with a QR code pasted on the poster to allow student-athletes to scan with their cell phones. This code would work in the same way as the provided link in the email and direct the student-athlete to the Qualtrics questionnaire. (3) At 1 athletic department, in addition to the email and poster recruiting process, in-person recruitment was performed during the weekly dinner involving all sports rosters.

Questionnaire

The web-based questionnaire was administered through Qualtrics (SAP), for which each question required a response to move forward. Recruitment was performed via email, posters, and in-person recruitment depending on the athletic program. The questionnaire, accessible through a link or QR code, was anonymous, and after completion, student-athletes were asked for a single-use code and linked to a separate questionnaire where personal information would be provided to receive a $17.50 virtual gift card for completion of the questionnaire. The single-use code was used to ensure that no duplicate responses were created. To ensure anonymity, names were not requested; additionally, IP addresses were only used to identify bot responses (ie, responses that were received without IP addresses were assumed to be bot-generated responses). After analysis, all identifying information, including the IP addresses, was removed from the dataset.

The questionnaire (see Supplemental File, available online at http://dx.doi.org/10.4085/1062-6050-0098.24.S1) consisted of 5 main categories as previously described by Wardenaar et al[20]:

- General questions (subtotal of 5 questions): athletic department, primary sport, sex, age, and athlete status.
- Information sources (subtotal of 10 questions): nutrition information and counseling, contact moments, topics addressed, preferred health professional, preferred information source, types of social media use, social media frequency, daily time spent on social media per day, social media use related to nutritional supplements and sports foods, and preferred way of contacting in case of new information.
- Supplement knowledge (subtotal of 16 questions): supplement section of the Nutrition for Sport Knowledge Questionnaire (NSKQ; 12 questions), supplements related to doping, World Anti-Doping Agency familiarity, contamination, and implications of a failed drug test.
- Nutritional supplement use (subtotal of 9 questions): age of first use, purchase outside athletic department, frequency of TPT supplements during the last 12 months, who purchases supplements, location of supplement purchase, estimated contamination of supplements, predefined supplement checklist, TPT of individual supplements, and TPT logo recognition.
- Attitudes and barriers (subtotal of 45 questions): find and order TPT supplements, common feelings and beliefs about TPT supplements (11 questions), strategies for safe supplement use, solutions and purchases of (safe) supplement use (18 questions), and personality traits (14 questions).

These questions were partly adapted from the published literature, with additional "original" questions created by the research team and combined into its current state.[1,20–22] Throughout the creation, the questionnaire was examined regularly for practicality and content validity by content experts (ie, sports nutrition professors and dietitians). This was combined with pilot testing among students, in which feedback was sought on the content and readability of the questions.[20] Finally, before the start of this study, a small pilot study was performed with collegiate athletes, which included test-retest reliability and assessment of internal consistency, of which the results were used to finalize the currently used questionnaire.

For this article, only the results of the questions that directly related to the student-athlete characteristics, their information sources, nutritional supplementation knowledge, and nutritional supplementation use were reported.[1,4,20,21] The information source questions asked if the athlete had received any nutritional counseling or advice from a Sports Registered Dietitian (RD), either provided by their athletic department or externally, or another source and, if so, how often these sources were used.[1] The nutritional supplementation knowledge questions assessed self-reported nutritional supplement knowledge using multiple choice questions and *agree*/*disagree*/*not sure*. This set of questions, with 12 items from the NSKQ, was previously validated, revealing a reasonable internal reliability based on the Kuder-Richard Formula 20 of 0.69 but a subpar internal consistency using Cronbach's α of 0.60.[1,23]

Determinants of Interest for Assessing Sex Differences

To assess meaningful sex differences, this article focuses on differences for sex between supplements reported, TPT use, the use of supplements outside of what their athletic departments provide, and the following new variables based on questionnaire results created for further analysis.

Nutritional Counseling. When analyzing sex differences, counseling was condensed into a binary variable (receiving nutritional counseling from at least 1 source versus not receiving nutritional counseling).

Nutritional Supplement Knowledge Score. The total nutritional supplement knowledge score was created as a percentage by taking the number of correct answers in the NSKQ section divided by the total number of questions (12) in that section. This section was in the latter portion of the survey (ie, after the 70% cutoff), resulting in a slightly smaller n size for this analysis.

Consistent TPT Use. The consistent TPT use percentage was created by categorizing self-reported TPT use into a binary variable (always reporting TPT for each supplement used versus not always reporting the use of TPT supplements) while removing athletes not reporting nutritional supplements.

To estimate the most accurate self-reported TPT supplement use, all sports foods that were likely to have a nutrient facts label (including sports drinks, sports bars, chocolate [flavored] milk, recovery drinks, energy drinks, and energy gels or chews) were removed from this specific analysis. As foods are produced under stricter regulations than dietary supplements, these products were not included in the analysis of products that were considered TPT. Athletes were categorized as consistent TPT users if they identified TPT for all their reported supplements, leaving out sports foods that likely had a nutrition facts label as we could not state with certainty that these products were manufactured with a supplement facts label or a nutrition facts label, and, therefore, we could not be sure that they would likely undergo TPT.

TPT Organization Logo Recognition. The TPT organization logo recognition variable was created by recording how many, if any, of the logos for 9 TPT organizations were recognized by the student-athlete and condensing the data into a binary variable (no recognition versus at least 1 logo recognized).

Statistical Analysis

Data were observed and analyzed using both Excel (Microsoft) and SPSS (IBM Technology Corporation). After cleaning the data in Excel, the final data set was converted to an SPSS file for data analysis. Most of the data were not distributed normally based on visual inspection of histograms and normal distributions and by using skewness and kurtosis. Therefore, demographics and descriptive data for nutritional supplement use and use of TPT nutritional supplements were reported as percentages (%) and frequencies (n) or as median and interquartile range (IQR). For the percentage of self-reported use of nutritional supplements and the fraction of TPT nutritional supplement use, a 95% CI was estimated. For this purpose, the formula $\hat{p} + z \times \sqrt{(\hat{p}(1 - \hat{p})/n)}$ was used, of which z is 1.96, $\hat{p}$ is the sample proportion of student-athletes using nutritional supplements or TPT nutritional supplements, and n is the (total) sample size. All 95% CIs were expressed as a value between 0% and 100%. Due to the explorative nature of the data collection, only stratifications were performed for sex. Differences between sex for the total reported count of nutritional supplements, reported count of TPT nutritional supplements, and nutritional supplement knowledge score were determined using a Mann-Whitney U analysis (with group size for females indicated by $n^1 = 217$ and males indicated by $n^2 = 193$). Other sex differences were assessed using χ^2 analyses and odds ratio (OR) predictions for purchase/use of supplementation outside of what has been provided by their athletic department, each individual nutritional supplement reported and its reported TPT, nutritional counseling, consistent TPT use, and TPT logo recognition. Statistical significance was determined for all tests at $P \leq .05$.

RESULTS

Total Group

The total number of responses from student-athletes from the 6 NCAA Division I athletic departments was n = 568 (14% response rate), with a range of 14 to 145 responses from each of the 6 individual departments. Before analysis, 91 questionnaires were excluded for lack of completion (as the athletes completed <70% of the questions), 62 responses were removed because of the selected age (≥35 years old), and an additional 5 questionnaires were removed because of duplicate responses. Data analysis was based on a total of n = 410 student-athletes (53% female, age = 21.0 years; IQR, 20.0 to 22.3 years), as shown in Table 1.

Purchasing Supplements Outside the Department. A total of 48% (n = 191, out of 402 responses) reported purchasing supplements outside of what was provided by their athletic department.

Combined Supplement Use and TPT Frequency. When analyzing total reported nutritional supplement use, including sports foods, 91% (n = 372) of the student-athletes reported the use of at least 1 nutritional supplement and reported a median total number of supplements used of 8, with an IQR of 4 to 12. When sports foods were excluded, 370 athletes reported the use of at least 1 supplement, and the median reported supplements used was 4 in total, with an IQR of 2 to 6. Of the 370 athletes who reported supplement use, 38% (n = 140) reported "consistent TPT use," indicating that all the supplements that they reported were also TPT.

Single Supplement Count and TPT Supplement Count. As shown in Table 2, the most frequently reported supplement used was sports drinks, such as electrolyte replacement beverages (72%, n = 294), of which 67% self-reported that these were TPT. Other popular supplements were protein shakes (65%, n = 267), of which 66% reported that their protein shake product of choice was TPT, and recovery drinks (57%, n = 234), of which 71% reported these as TPT. More than half of the athletes reported caffeine usage (56%, n = 229), with only 42% of those users reporting that the product was TPT (n = 96). Finally, of the creatine users (22%, n = 91), the majority reported that the products they selected were TPT (79%, n = 72). All other self-reported supplement and TPT use scores can be found in Table 2.

Nutrition Counseling. When analyzing information sources, 89% (n = 366) reported receiving information from their respective departmental RD, whereas 8% (n = 33) reported visiting an RD from an external source that was not in their athletic department. In addition, 2% (n = 9) of the student-athletes reported receiving nutritional information from an "other" person or profession. Finally, 8% (n = 31) of the student-athletes reported not having received any nutritional information, counseling, or advice during the last 12 months.

TPT Logo Recognition. A total of 66% (n = 271) of the participants reported recognizing at least 1 TPT logo. Only 34% (n = 92) of the student-athletes that recognized at least 1 TPT organization logo reported consistently using TPT nutritional supplements, whereas 38% (n = 104) reported sometimes using TPT supplements and 20% (n = 54) reported never using TPT supplementation. Conversely, of the 33% (n = 133) of the student-athletes who reported no recognition of TPT organization logos, 35% (n = 46) reported consistently using TPT nutritional supplements, 29% (n = 38) reported sometimes using TPT supplementation, and 23% (n = 30) reported never using TPT supplements. Lastly, of the 46 who had no recognition of TPT logos and reported consistently using TPT supplements, 65% (n = 30) reported not purchasing supplements from sources outside of their athletic department. We assumed that those athletes reporting to select TPT supplements should also be able to more frequently recognize TPT organization logos. Out of 404 student-athletes, 67% (n = 271) reported to recognize at least 1 out of 9 TPT organization logos, but no clear relation existed between TPT logo

Table 1. Demographics of the Collegiate Athletes Surveyed (N = 410) Continued in Next Column

	n (%)
Sex	
Female	217 (53)
Male	193 (47)
Age, y	21.4 ± 1.6
Sport (n = 409)[a]	
Baseball (M)	24 (6)
Basketball (M)	7 (2)
Basketball (W)	4 (1)
Beach volleyball (W)	8 (2)
Cheerleading (M)	2 (0.5)
Cheerleading (W)	5 (1)
Cross country (M)	6 (2)
Cross country (W)	16 (4)
Dance (W)	7 (2)
Fencing (W)	6 (2)
Field hockey (W)	11 (3)
Football (M)	42 (10)
Golf (M)	9 (2)
Golf (W)	8 (2)
Gymnastics (M)	2 (0.5)
Gymnastics (W)	7 (2)
Ice hockey (M)	8 (2)
Lacrosse (M)	16 (4)
Lacrosse (W)	6 (2)
Rowing (M)	1 (0.2)
Rowing (W)	2 (0.5)
Skiing (M)	4 (1)
Skiing (W)	7 (2)
Soccer (M)	9 (2)
Soccer (W)	24 (6)
Softball (W)	22 (5)
Swimming and diving (M)	16 (4)
Swimming and diving (W)	33 (8)
Tennis (M)	7 (2)
Tennis (W)	9 (2)
Track and field (M)	27 (7)
Track and field (W)	23 (6)
Volleyball (W)	7 (2)
Water polo (W)	11 (3)
Wrestling (M)	13 (3)
Athlete type (student-athletes could select multiple options)	
Carded athlete	8 (2)
Part of national doping testing pool	14 (3)
Member of national team or selection	32 (8)
Student-athlete at a US collegiate AD	397 (97)
Student-athlete not at a US collegiate AD	5 (1)
Professional athlete	4 (1)
Other	4 (1)
Have received nutrition information, counseling, or advice during the last 12 months from any of the people or professions[b]	
Sports RD within AD	366 (89)
Sports RD outside of AD	33 (8)
Other	9 (2)
I have not received nutrition information	31 (8)
Number of visits completed for nutrition information, counseling, or advice during the last 12 months[c]	
Sports RD within AD (n = 355)	
1–2 visits	114 (32)
3–6 visits	148 (42)
7–10 visits	50 (14)
11 or more visits	43 (12)
Sports RD outside of AD (n = 29)	
1–2 visits	15 (52)
3–6 visits	10 (35)
7–10 visits	3 (1)
11 or more visits	1 (<1)
Other (n = 6)	
1–2 visits	3 (50)
3–6 visits	0 (0)
7–10 visits	1 (17)
11 or more visits	2 (33)

Table 1. Continued From Previous Column

Abbreviations: AD, athletic department; M, men's sport; RD, registered dietitian; W, women's sport.

[a] One response could not be placed in a category as the athlete indicated to be female while selecting men's track and field.

[b] Percentages may not add to 100% as student-athletes could select multiple options.

[c] Samples based on previous question response; student-athletes could select only 1 option.

recognition (no recognition versus 1+ logo recognized) and the consistent use of TPT supplements (always versus not always; $\chi^2 = 0.238$, $P = .63$).

Nutritional Supplement Knowledge Score. Student-athletes reported a median score of 33% with an IQR of 8% to 42% for the nutritional supplement portion of the NSKQ. As individual NSKQ outcomes ranged from 0% to 42%, none of the student-athletes (n = 404) scored more than half of the test correctly.

Sex Differences

Purchasing Supplements Outside the Department. Female athletes purchased nutritional supplements outside the athletic department less often than male athletes ($\chi^2 = 11.2$, $P < .001$). A total of 40% (n = 84) of female and 56% (n = 107) of male athletes reported purchasing or using supplementation outside of what has been provided by their athletic department. Male athletes were shown to be at 0.5 times greater odds (95% CI, 0.3–0.8) of purchasing or using supplementation outside of what has been provided by departments.

Combined Supplement Use and TPT Frequency. When examining total reported supplement use, a significant difference was seen. Female athletes reported a median total number of supplements used of 7 (IQR, 4–11), and male athletes reported using 9 (IQR, 4–12) nutritional supplements per person (Mann-Whitney $U = 17\,960$, $P = .01$). The majority of both sexes reported the use of supplements (90% [n = 196] of females versus 93% [n = 178] of males, OR = 1.27, $P = .5$; 95% CI, 0.64–2.54). When excluding food products, 90% (n = 195) of females and 91% (n = 175) of males reported supplement use (OR = 1.47, $P = .22$; 95% CI, 0.8–2.71). Of those reporting supplement use, fewer female (32%, n = 63/195) than male (44%, n = 77/175) athletes reported TPT use (OR = 1.65, $P = .02$; 95% CI, 1.08–2.51).

When analyzing nutritional supplement use, not including sports foods, female athletes reported a median total number of supplements used of 4 (IQR, 2–6), and male athletes reported using 5 nutritional supplements per person (IQR, 2–7). A significant sex difference was also seen for the total number of supplements used when excluding sports foods (Mann-Whitney $U = 18\,010$, $P = .01$).

When analyzing TPT use, not including sports foods, female athletes reported a median total number of TPT supplements used of 5 (IQR, 1–8), and male athletes reported using 6 nutritional supplements per person (IQR, 2–10). This was a

Table 2. Self-Reported Nutritional Supplement Use and Third-Party Testing (TPT) Use Divided Into Dietary Supplements, Sports Foods, and Ergogenic Supplements

	Total Use			TPT Use		
	%	95% CI	n	%	95% CI	n
Dietary supplements						
Single vitamin	47	42–52	194	68	61–74	131
Multivitamin and mineral supplement	46	42–51	190	69	62–76	131
Single mineral	31	26–35	125	71	62–78	88
Fish oil/essential fatty acids	29	24–33	118	76	69–84	90
Combination of vitamins	24	20–29	100	63	54–72	63
Combination of minerals	9	6–11	35	77	63–91	27
Sports foods[a]						
Sports drinks	72	67–76	294	67	61–72	196
Protein shake[b]	65	61–70	267	66	60–71	175
Recovery drink	57	52–62	234	71	66–77	167
Sports bar	56	51–61	230	62	56–68	143
Chocolate (flavored) milk	54	49–58	220	63	56–69	138
Energy gels or chews	40	35–45	165	60	53–67	99
Energy drinks	39	34–43	159	43	35–50	68
Weight gainer[b]	5	3–8	22	86	72–100[d]	19
Ergogenic supplements[c]						
Caffeine	56	51–61	229	42	36–48	96
Tart cherry	34	30–39	141	72	65–80	102
Creatine	22	18–26	91	79	71–87	72
Probiotics	18	14–22	74	65	54–76	48
Preworkout	17	13–20	69	54	42–65	37
Exotic berries (such as açai and gogi)	12	9–15	49	41	27–55	20
Dietary nitrate	7	4–9	27	78	62–93	21
Branched-chain amino acids	6	4–9	26	65	47–84	17
β-Alanine	6	4–8	25	84	70–98	21
Herbs (such as echinacea, ginseng, or other herbs)	4	2–5	15	73	51–96	11
Ashwagandha	4	2–5	15	60	35–85	9
L-Carnitine	3	1–5	13	38	12–65	5
Cannabidiol	3	1–4	11	45	16–75	5
Leucine	2	1–4	10	80	55–105	8
Maca root powder	2	1–3	8	63	29–96	5
Kava	1	0–3	6	17	0–46	1
Sodium bicarbonate, glucosamine	1	0–2	4	75	33–117	3
Fenugreek	0.5	0–1	2	0	—	0
Quercetin	0.5	0–1	2	100	—	2
Glycerol	0.2	0–1	1	0	—	0
Hydroxymethylbutyrate, colostrum, ribose, MCT	0.2	0–1	1	100	—	1

Abbreviation: MCT, medium-chain triglyceride.

[a] These sports foods may be produced with a nutrition facts label, and therefore they may be subject to different Food and Drug Administration standards than nutritional supplements; as such, the need of TPT for these products should be determined on a case-by-case basis, and results for TPT use should be interpreted with caution.

[b] Protein shakes and weight gainer supplements are considered macronutrient-based sports food that in most cases carry a supplement fact label; as such, TPT is advised.

[c] Selective androgen receptor modulators, tribulus terrestris, ephedra, dendrobium, methylliberine, longjack, and Phyllanthus (or leaf-flower) were not reported by any athlete.

[d] Calculated CI = 101% and was rounded to 100%.

significant difference (Mann-Whitney $U = 13\,536$, $P < .001$). Overall, female athletes (36%, n = 70) reported consistent TPT use less often than male athletes (41%, n = 70; $\chi^2 = 0.952$, $P = .33$).

Single Supplement Count and TPT Supplement Count. When analyzing individual products, female athletes were less likely than male athletes to report the use of combination mineral supplements (4%, n = 9 versus males 14%, n = 26), preworkout supplements (7%, n = 15 versus males 29%, n = 54), branched-chain amino acids (1%, n = 3 versus males 12%, n = 23), β-alanine (1%, n = 15 versus males 12%, n = 22), dietary nitrate (3%, n = 7 versus males 10%, n = 20), and creatine (7%, n = 14 versus males 40%, n = 77; $P \leq .001$ for all of these comparisons, as shown in Table 3). When comparing individual TPT product use, female athletes were less likely than male athletes to use TPT versions of caffeine (29%, n = 36 versus males 57%, n = 60) and probiotics (55%, n = 26 versus males 82%, n = 22; $P < .02$, as shown in Table 3).

Nutrition Counseling. Nearly all athletes reported receiving at least 1 source of nutritional counseling regardless of sex (females: 93% [n = 203]; males: 91% [n = 176]). No significant differences in sex were identified for whether an athlete received nutritional counseling (Mann-Whitney $U = 20\,447$, $P = .37$).

TPT Logo Recognition. Female athletes recognized TPT organization logos less often than male athletes when we

Table 3. Sex Differences in Self-Reported Nutritional Supplement Use and Third-Party Testing (TPT; N = 410)[a]

	Overall Supplement Use (Users)				TPT Use (Users)			
Supplement Used	Women, % (n = 217)	Men, % (n = 193)	OR (95% CI)	*P* Value	Women, n (%)	Men, n (%)	OR (95% CI)	*P* Value
Dietary supplements								
Single vitamin	58	36	0.41 (0.28–0.61)	<.001	79/125 (63)	52/69 (75)	1.78 (0.92–3.44)	.08
Multivitamin and mineral	46	47	1.02 (0.69–1.51)	.91	65/100 (65)	66/90 (73)	1.48 (0.8–2.76)	.22
Single mineral	40	20	0.37 (0.23–0.57)	<.001	63/87 (72)	25/37 (68)	0.79 (0.79–1.83)	.59
Fish oil/essential fatty acids	19	40	2.85 (1.83–4.45)	<.001	30/41 (73)	60/77 (78)	1.29 (0.54–3.11)	.56
Combination of vitamins	21	28	1.44 (0.92–2.27)	.11	25/46 (54)	38/54 (70)	2.00 (0.88–4.54)	.10
Combination of minerals	4	14	3.6 (1.64–7.89)	<.001	5/9 (56)	22/26 (85)	4.40 (0.81–23.90)	.07
Sports foods								
Sports drinks	73	71	0.89 (0.58–1.37)	.59	—	—	—	—
Protein shake	56	76	2.42 (1.58–3.70)	<.001	70/122 (57)	105/145 (72)	1.95 (1.17–3.25)	.01
Recovery drink	50	65	1.86 (1.25–2.78)	.002	—	—	—	—
Sports bar	57	56	0.97 (0.66–1.44)	.88	—	—	—	—
Chocolate (flavored) milk	48	61	1.74 (1.18–2.58)	.006	—	—	—	—
Energy gels or chews	44	37	0.75 (0.5–1.11)	.15	—	—	—	—
Energy drinks	32	46	1.8 (1.2–2.69)	.004	—	—	—	—
Weight gainer	2	9	5.48 (1.82–16.48)	<.001	3/4 (75)	16/18 (89)	2.67 (0.18–39.63)	.46
Ergogenic supplements								
Caffeine	57	55	0.91 (0.62–1.35)	.65	36/124 (29)	60/105 (57)	3.26 (1.89–5.64)	<.001
Tart cherry	36	32	0.83 (0.55–1.25)	.36	57/79 (72)	45/62 (73)	1.02 (0.49–2.15)	.96
Creatine	7	40	9.63 (5.21–17.8)	<.001	10/14 (71)	62/77 (81)	1.65 (0.46–6.00)	.44
Probiotics	22	14	0.59 (0.35–0.99)	.04	26/47 (55)	22/27 (82)	3.55 (1.15–10.99)	.02
Preworkout	7	29	5.37 (2.92–9.88)	<.001	7/15 (47)	30/54 (56)	1.43 (0.45–4.50)	.54
Exotic berries	14	10	0.68 (0.37–1.25)	.22	10/30 (33)	10/19 (53)	2.22 (0.68–7.22)	.18
Dietary nitrate	3	10	3.47 (1.43–8.4)	.004	6/7 (86)	15/20 (75)	0.50 (0.05–5.22)	.56
Branched-chain amino acids	1	12	10.13 (3.00–34.2)	<.001	1/3 (33)	16/23 (70)	4.57 (0.354–59.11)	.22
β-Alanine	1	12	9.18 (2.70–31.2)	<.001	2/3 (67)	19/22 (86)	3.17 (0.22–46.73)	.38
Herbs	3	5	1.72 (0.60–4.92)	.31	3/6 (50)	8/9 (89)	8.00 (0.58–110.27)	.10
Ashwagandha	3	5	1.72 (0.60–4.92)	.31	2/6 (33)	7/9 (78)	7.00 (0.69–70.74)	.09
L-Carnitine	1	6	6.5 (1.42–29.7)	<.01	1/2 (50)	4/11 (36)	0.57 (0.03–11.85)	.72
Cannabidiol	3	2	0.64 (0.18–2.2)	.47	2/7 (29)	3/4 (75)	7.50 (0.46–122.70)	.14
Leucine	1	4	2.69 (0.68–10.5)	.14	1/3 (33)	8/8 (100)	—	.01
Maca root	2	2	1.13 (0.28–4.57)	.87	2/4 (50)	3/4 (75)	3.00 (0.15–59.89)	.47
Kava	1	2	2.28 (0.41–12.6)	.33	0/2 (0)	1/4 (25)	—	.44
Glucosamine	0.5	2	3.41 (0.35–22.1)	.26	1/1 (100)	2/3 (67)	—	.51
Sodium bicarbonate	1	1	1.12 (0.16–8.07)	.91	1/2 (50)	2/2 (100)	—	.25
Fenugreek	1	0	—	.18	0/2 (0)	—	—	—
Quercetin	0	1	—	.13	—	2/2 (100)	—	—
Glycerol	0	1	—	.13	—	1/1 (100)	—	—
Hydroxymethylbutyrate	0	1	—	.13	—	1/1 (100)	—	—
CLA	0	0.5	—	.29	—	1/1 (100)	—	—
MCT	0	0.5	—	.29	—	1/1 (100)	—	—
Ribose	0	0.5	—	.29	—	1/1 (100)	—	—
Colostrum	0	0.5	—	.29	—	1/1 (100)	—	—
All other supplements[b]	—	—	—	—	—	—	—	—

Abbreviations: CLA, conjugated linoleic acid; MCT, medium-chain triglyceride; OR, odds ratio.

[a] Supplement use and TPT proportions were calculated for all individual supplements. These calculations were not performed for 6 of the sports foods as we were not able to confirm whether these products would truly be subject to TPT. Sex differences were assessed using χ^2 analyses and OR predictions, and CIs were calculated manually. For supplements with less than 5 comparisons, no χ^2 analyses were calculated. Significance was set a priori at $P \leq .05$.

[b] Other supplements: ephedra, tribulus terrestris, selective androgen receptor modulators, dendrobium, methylliberine, longjack, and *Phyllanthus*.

classified responses into 2 categories: recognizing at least 1 logo versus no logo recognition ($\chi^2 = 16.6$, $P < .001$). A total of 42% (n = 90) of the females versus 23% (n = 43) of the males reported not recognizing any TPT organization logos. In addition, male athletes had 2.5 times greater odds of recognizing at least 1 TPT organization logo than their female counterparts (OR = 2.45; 95% CI, 1.58–3.79).

Nutritional Supplement Knowledge Score. There were no sex differences for total NSKQ score (females, 33%; IQR, 8–33%; males, 33%; IQR, 8%–42%; Mann-Whitney $U = 19\,947$, $P = .38$).

DISCUSSION

The aim of this study was to investigate NCAA Division I collegiate athletes' nutritional supplement use, the portion of self-reported TPT supplements, and the level of knowledge surrounding TPT products and TPT organization logos. Nine out of 10 NCAA Division I collegiate athletes questioned reported the use of nutritional supplements. However, a large proportion of these athletes reported inconsistent use of TPT supplements. General supplement knowledge and recognition of TPT organization logos was low.

In addition, this study explored sex differences for these outcomes. The majority, both female and male participants, received some form of nutritional counseling. Males purchased supplements more often outside the athletic departments and recognized TPT organization logos more often than females, but overall, no difference was seen for sex for TPT supplement use.

Nutritional Supplement Use

Nearly all the athletes in the current study reported the use of nutritional supplementation. This was similar to (but on the higher end) than that observed in previous studies in athletes, which ranged from 45% to 89% self-reported supplement use.[4,16,24–28] In general, it is common for athletes to use nutritional supplements; however, the total number of supplements could be related to the sampled population with self-reported use in higher-level athletes.[29] The current study examined supplement use by athletes participating in NCAA Division I collegiate sports, the highest level of collegiate athletics in the United States. These Division I programs are often being better funded than Division II, Division III, or Junior College programs; therefore, Division I athletes may have more resources provided to them by their department, such as NCAA-permissible products, which include carbohydrate electrolyte drinks, energy bars, carbohydrate boosters, vitamins and minerals, protein supplements, and omega-3 fatty acids.[30,31] This may especially inflate the use of these permissible nutritional supplements in student-athletes at Division I athletic departments compared with student-athletes in departments with less funds available. On the other hand, impermissible supplements are any products that fall outside of the previously defined permissible list, and these products cannot be provided by athletic departments but may be purchased by athletes at their own risk.[30]

Many of the Division I athletes in the current sample reported purchasing nutritional supplements outside of what their athletic department provides. The most reported supplements were protein drinks and caffeine.[1,32,33] It seems that the use of protein supplements increased over the last 15 years, with the literature reporting a rise of protein supplementation reported by athletes from 22% to 55% more recently, and currently, nearly two-thirds of this sample reported the inclusion of protein supplementation in their diet.[24,34] Similarly, the inclusion of caffeine to enhance performance, in the form of beverages such as energy drinks, is currently highly prevalent in collegiate athletics.[25] Additionally, the use of caffeine-containing products by college students has been reported as rising over the past 10 years, ranging from 30% to 50% in 2011 to 92% in 2019.[35,36] The use of sports drinks has been reported to range between 22% and 77%, and the data extracted from this sample falls on the high end of that range.[37,38] Likely, the high reported use of both protein supplements and sports drinks may be the result of the availability of sports foods provided by their athletic departments at their fuel stations as well as a high athlete conformity to its use. The stark increase in caffeine intake seen in collegiate athletes may be related to the general rise in caffeine use in collegiate students.

TPT Products and Logo Recognition

A strength of this study was to question TPT use for individual supplements compared with earlier studies asking if athletes used TPT supplements as a general question, which likely overestimated compliance.[1,39] Concerningly, when separating out TPT use per supplement, only 38% of athletes using supplementation consistently reported TPT supplements, which is substantially lower than that of previously reported general TPT use, falling around 60%.[1,39] This may be a cause for concern, as contamination, adulteration, and/or spiking in nutritional supplements is possible and prevalent.[40] It is well understood that the use of products that have undergone examination by TPT organizations have reduced risk of contamination, but little is understood about the knowledge of athletes when it comes to these organizations or whether athletes know which organizations can be trusted. In the current study, athletes were not prompted further than reporting if they recognized 1 or more of the most common TPT organization logos, so continued study into the relation between this knowledge and actual TPT use is warranted. However, it has been suggested earlier that reasoning for non-TPT compliance could be the result of athletes not knowing they should check, not regarding the testing as being important, or being unable to find the product in a TPT form.[39]

Two-thirds of the current sample (66%) recognized at least 1 TPT organization logo, which was 1.5 times greater than the response from a high school sample that we recently questioned, which reported that only 44% of the sample recognized at least 1 logo.[41] At the high school level, it was identified that those who self-reported the use of more than 1 TPT supplement were more inclined to recognize TPT organization logos (49%),[41] and in the current sample, only 34% of those who recognized at least 1 TPT logo reported consistent TPT supplement use.

Interestingly, one-third of those who did not recognize any of the provided TPT organization logos still reported consistently using TPT supplements. Supplements being supplied to athletes by athletic departments are typically overseen by an RD, so it can be assumed that athletes may solely rely on their athletics department providing supplements, as only one-quarter of these athletes reported purchasing nutritional supplements outside of what is provided by their department. Most of this sample reported having access to an RD, and it has been reported that an athlete who discusses their supplementation with sports dietitians is associated

with consistently using TPT supplementation.[41] Because of this, it could be assumed that athletes who receive supplementation from their athletic department directly, and do not purchase externally, may not be that familiar with TPT organizations and their logos. Additionally, it is understood that competitive athletes who have access to nutritional counseling are more likely to make better informed decisions regarding supplement use.[4] It was identified that no difference for TPT logo recognition was seen when comparing those who consistently used TPT products with those who did not. This could also result from the chance that athletes are consistently using products supplied by their athletic department, and based on the current data collection (Wardenaar et al[42]) and our previous finding in high school athletes, we conclude that TPT logo recognition is unlikely to be a good predictor of TPT supplement use.[41] Overall, the present study shows that TPT compliance is concerningly low; however, athletes who rely solely on supplementation provided by their athletic departments may be at a reduced risk as these products should be compliant with TPT.

Sex Differences in Collegiate Athlete Nutritional Supplement Use and Knowledge

Female athletes were less likely to purchase additional supplements outside of what is provided by their athletic department than their male counterparts. Less than half (40%) of female athletes versus more than half of their male counterparts (56%) purchased additional supplements externally. In addition, although not significant, the female athletes in the current sample reported greater use of permissible products, which may be assumed to be provided by the department, including single vitamins, single minerals, sports drinks, and sports bars, which may provide context for why female athletes, at this level, did not report external purchase as frequently as male athletes.[27] It was previously reported that Division I female athletes are less likely than their male counterparts to use more than 3 supplements and are more likely to use supplements such as vitamins and minerals.[27] Although the sample in the current study reported greater nutritional supplement use than previous studies, the female/male supplement use ratio mimicked their findings, indicating that females have a slightly lower inclination to use supplements than males.[18,27] As seen in our results, there were no differences reported for access to a sports dietitian; however, it was previously reported that female athletes are more likely to use this service, whereas male athletes are more inclined to rely on themselves for supplement use planning behavior.[18] It may be assumed that this could lead to an increase in external purchase of products rather than using strictly what may be provided by the athletic department.

When examining individual products, female athletes were less likely to use combination mineral supplements, branched-chain amino acids, β-alanine, and creatine than male athletes, following suit with previous studies.[1,27,38] Females in the present study were less inclined to use dietary nitrate and, similar to previous studies, less frequently used preworkout supplements.[34,43] Both of these supplements can be classified as (potential) ergogenic aids. Preworkout supplements have been identified as risky because dangerous stimulants, including a methamphetamine analog and 1,3-dimethylamylamine, have been identified in mainstream preworkout supplements.[44,45] The discrepancy between sexes for the use of ergogenic aids is consistent with previous studies and may be linked to the purpose of use as well as the purchase of supplements externally, reporting that male athletes are more likely to report the use of ergogenic substances than female athletes.[43,46,47] The increased reporting of these ergogenic supplements in males, especially those that are seen as risky, may lead to an increased doping risk for male athletes. Finally, given that NCAA athletic departments are restricted from providing supplementation beyond the permissible supplements, male student-athletes may purchase supplements beyond this list externally for their assumed ergogenic effects more frequently than female student-athletes.[30]

One strength of this study was its anonymous survey of athletes for information regarding their supplement use and behavior, as the negative connotation around supplementation may make it difficult to gather data when participants fear the threats of disclosure and consequence.[48] Reduced feelings of concern for judgment and fear of consequence may increase the likelihood of honesty from the athletes surveyed anonymously.[49] In addition, these data included athletes from 6 athletic departments being part of Power 5 conferences (ie, considered the most prominent within collegiate athletics) spread across the United States, thus providing a broader sample population than most previous studies focusing on collegiate athletes.[1,27,43] Further, the novelty of asking TPT for supplements individually, rather than in general, provided this study with the opportunity to identify consistency of TPT use. Finally, the study included a reasonable equal distribution of female and male athletes.

This study was not without limitations. To begin, sport professionals should be aware of the generalizability of these results. Although the sample estimate was based on the population size for athletes from NCAA Division I to Division III, our study only represents responses from Division I institutions, and it is understood that these programs may have more access to RDs and nutritional education, offering meal planning and snacks to athletes.[50] So, as such, these results are mainly associated with the Division I level and should be used with caution if applied to the Division II or Division III levels, as differences may exist.[31] The use of self-report survey tools has a built-in potential for answers to be biased or inaccurate; this includes our inability to confirm TPT of the reported supplementation. Because these findings are self-reported, it cannot be determined if the athlete uses a TPT supplement. Additionally, athletes may answer dishonestly for many reasons, such as fear of consequence or disinterest. As a result, there may be error in the accuracy of these percentages regarding the actual number of TPT supplement use. One additional limitation resulted from a restricted budget; as a result, recruitment was capped at 13% to 14% to ensure that all participants could be incentivized. Additionally, as a result of the low response rate in the present study, the discussion regarding differences of nutritional supplement use and TPT use and knowledge between sports has yet to be examined. It is suggested that future studies be powered to examine these possible differences. Further, it was seen that athletes reported TPT for non-sport-food items (ie, not created as a supplement), such as milk, which are not tested. Therefore, we need to assume that some athletes considered all products provided by their athletic departments as TPT. At the same time, certain sports foods could be provided with a nutritional facts label instead of a supplement facts label. These are the different reasons why we excluded sports foods, that could be produced as non-sport-food (and not as a supplement)

from further calculations assessing consistent TPT use. In addition, we were not able to exactly determine their method of caffeine use. Although they could report the use of energy drinks, caffeine is nowadays also (sometimes) added to sports drinks, energy gels or chews, and other supplements. Finally, the method we used to calculate the 95% CI for supplement use may overestimate the interval for supplements with a low self-reported prevalence.

In conclusion, supplement use in collegiate athletes was high. On average, athletes reported the use of 8 different nutritional supplements during the last 12 months, with nearly every athlete surveyed reporting at least 1 nutritional supplement. Although many of the athletes reported recognition of TPT organization logos, an athlete's consistency of TPT use was not found to be linked to this recognition. Concerningly, most of these athletes did not consistently report using TPT products and had very low nutritional supplement knowledge scores. In general, female athletes reported a slightly lower number of supplements used than male athletes, with a lower percentage of TPT supplements as well as lower recognition of TPT organization logos, while relying slightly more often on the supplements provided by their athletic department than purchasing externally like their male counterparts. The education that athletes are receiving through their athletic department should focus more on where to find and order TPT supplements.

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SUPPLEMENTAL MATERIAL

Supplemental File. Questionnaire.

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