

Nutrition and physical performance

Knowledge, Prevalence, and Consequences of Dietary Supplements Intake among Iranian Bodybuilders



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ABSTRACT

Background: This study investigated the nutritional knowledge and prevalence of dietary supplements (DSs) among Iranian bodybuilders. **Methods:** This cross-sectional research study involved sampling 648 bodybuilding clubs in Iran. A researcher distributed questionnaires among clubs in various regions and analyzed categorical variables, DS, nutritional knowledge, and sports nutrition data from 160 bodybuilders aged 18 and above in Iran. The analysis was conducted using the results obtained from a quantitative questionnaire.

Results: There was a significant relationship between DS use and gender ($P = 0.001$, $r = 0.330$, males > females), bodybuilding history ($P = 0.045$; $r = 0.158$), and exercise sessions/wk ($P = 0.050$, $r = 0.156$). Whey protein (45.6%) and branched-chain amino acid (33.7%), vitamin D (50%), caffeine (34.3%), and generally vitamin C (56.2%) were the most common DS used. The most information sources for bodybuilders regarding DS were fitness coaches (35.6%) and registered dietitians/nutritionists (34.3%). Drug stores (36.7%) and fitness coaches (19.3%) were the most prominent sources for purchasing DS. Increasing performance (54.3%), increasing the need for DS through exercise (53.6%), preventing injury, and improving recovery (36.2%) were the most important reasons to consume DS. Skin problems (21.0%), increased liver enzymes (10.8%), and hair loss (9.4%) were the most common side effects of DS use. Total nutritional knowledge (macronutrients, micronutrients, and sports nutrition) was 58.6%.

Conclusions: This study concluded that fitness coaches and registered dietitians/nutritionists were the most common information sources for bodybuilders. It also revealed a moderate level of nutrition knowledge among bodybuilders. The most commonly used DS were vitamins C, D, and whey protein. Also, gender, bodybuilding history, and exercise sessions had a significant relationship with the prevalence of DS. However, the study also revealed some concerning findings; bodybuilders commonly experienced adverse side effects such as skin rashes, increased liver enzymes, and hair loss.

Keywords: dietary supplements, nutrition knowledge, bodybuilding, micronutrients, macronutrients

Introduction

Bodybuilding, also known as “the use of progressive resistance exercise to develop muscle building by hypertrophy,” has increased in popularity, competitively, and recreationally [1]. Bodybuilding is an art and a culture, not just a sport [2]. Unlike other sports, bodybuilding success is judged on appearances of symmetry and muscular definition rather than athletic performance [3]. Bodybuilders use resistance training plans and specific diets to increase muscle mass, sustain symmetry, and maintain low body fat levels [3]. Bodybuilding’s training plans

are separated into 4 periods: off-season, pre-contest, peak week, and post-contest. Each period has a particular spectrum of exercise type (multi- or single-joint), total training volume, and intensity load [4].

Availability and interest in nutritional details related to dietary supplements (DSs) are growing among athletes, especially bodybuilders [5]. Adequate nutritional knowledge is vital to improving athletic practice and health [6]. Coaches, athletic trainers, parents, teammates, fitness trainers, DS manufacturers, and the media are the primary sources of information for athletes [5]. Many athletes do not have the appropriate knowledge and

Abbreviations: BCAA, branched-chain amino acid; DS, dietary supplement.

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attitude toward DS and their efficacy and safety issues [7,8], because very few athletes get advice or information from educated sources such as registered dietitians or medical doctors [9,10]. Additionally, constant educational programs on nutrition and DS are not available in many countries, particularly developing ones. Lack of constant educational programs may lead to poor athletic performance and posing health hazards [11]. Compared with other athletes, bodybuilders are more likely to use DS to increase their adaptation to physical performance and training [9,12], and vitamins, minerals, protein powders or liquids, and amino acids are the most common DS currently used [13].

Numerous studies have shown adverse effects of DS consumption, including metabolic, hematological, cardiovascular, and neurological problems [14,15]. Also, because of the contamination of DS ingredients [16], it has been revealed that a risk factor for illicit drug misuse (which may cause so-called inadvertent doping) is the use of DS [17,18].

The prevalence of DS use differs across studies; for example, in bodybuilders, 100% [12], among people who exercise at a commercial gym, 84.7% [19], in young bodybuilders, 81.3% [20], among Brazilian male resistance training practitioners and bodybuilders, 76.9% [21], in Iranian athletes, 64.8% [22], among people who exercise at gyms, 64.7% [23], in elite Spanish athletes, 64% [24], among gym users in a university community and gym members in Portugal, 43.8% [9,25], among gym trainees in Tanta city, Egypt, 38.2% [26], and 36.8% among people exercising in gyms [27]. These variations in prevalence highlight the need for further research to understand the factors influencing DS use in different populations and to develop targeted interventions to promote the safe and effective use of DS. Finamore et al. [28] discovered that only 47.3% of respondents had adequate nutrition knowledge of sports. Regardless, Jovanov et al. [10] found that <40% of athletes knew the proper and intended use of protein, creatine, amino acids, beta-alanine, and glutamine. According to Finamore et al. [28], males achieved higher nutrition knowledge than females; however, Smith-Rockwell et al. [29] reported the opposite findings.

Goston and Correia [27], Oliver et al. [30], and Ruano and Teixeira [25] all found that the most commonly ingested types of DS were proteins and amino acids. Nonetheless, Morrison et al. [19] found that multivitamins and minerals were the most commonly ingested types of DS. The most prevalent sources of information in the study of Denham [31] and a study by Nabuco et al. [32] were fitness coaches; nevertheless, Aljaloud and Ibrahim [33] and also Silva et al. [21] demonstrated that the most common source of information was from a medical doctor. The result of research conducted by Baltazar-Martins et al. [24] found that most athletes bought DS from a store. At the same time, 24% got DS from a sponsor or internet website [24], which is inconsistent with Muwonge et al. [35]. The study by Muwonge et al. [35] found that the 3 most popular suppliers of DS were registered dietitians/nutritionists, retail stores, and pharmacies.

Because of the conflicting results between the studies and the need for comprehensive and detailed research done in Iran on nutritional knowledge, eating habits, DS consumption, and its consequences among bodybuilders, it seems necessary to conduct the present research. This study investigated the knowledge, prevalence, and consequences of DS intake among bodybuilders in Isfahan City.

Methods

Study design and population of the study

Cross-sectional research that analyzes data from 160 bodybuilders with ≥ 5 y of experience in bodybuilding has been performed (Figure 1). The participants in this research included all the bodybuilders of Isfahan City over 18 y old. Because of the difficulty of accessing the list of all athletes and bodybuilding coaches in Isfahan City, some of the bodybuilding clubs were randomly selected from among the 648 gyms in Isfahan City, and the researcher randomly distributed the questionnaires among the clubs in different regions of Isfahan. Data collection was performed in September 2020 with a quantitative questionnaire. The inclusion criteria for the gyms were that they be located in Isfahan. Inclusion criteria for athletes over 18 y old, who had weekly (≥ 3 d/wk) resistance training for ≥ 5 y, and could comprehend questionnaire items without regard to skin color, sex, social group, or class. In this study, resistance training is a form of physical activity designed to improve muscular fitness by exercising a muscle or a muscle group against external resistance [34]. Exclusion criteria were empty questionnaires and questionnaires from subjects under 18 y old. A total of 247 questionnaires were collected randomly. According to the research's exclusion criteria, 87 questionnaires were removed, and 160 questionnaires remained. Before the intervention was implemented, the study procedures were explained to the participants, and consent was obtained (Figure 1). This study was conducted according to the Declaration of Helsinki and was approved by the Human Research Ethics Committee of Shiraz University.

Method of data collection

The researcher was present at each club at different times of the day, explaining the goals and importance of the research to the athletes. The volunteers who were interested in participating in the research received the questionnaire.

The quantitative questionnaire, a combination of previous questionnaires implemented before and has 4 sections, was used [36–40]. In addition, the questionnaire used in this study was prepared by a researcher using valid questionnaires such as the Athlete Food Choice Questionnaire, General Nutrition Knowledge Questionnaire, and Sports Nutrition Knowledge Questionnaires [41,42]. In the first section, categorical variables were screened, including gender, age group, education, job, weekly training frequency, and nutrition course participation. The second part of the questionnaire is about DS, which examines the prevalence of different kinds of DS (protein, amino acids, vitamins, minerals, weight loss, and immune system stimulants) and the reasons for using and not using DS by bodybuilders. It also includes questions to investigate the adverse effects of taking DS. The questionnaire's third part measures nutritional knowledge, covering macronutrients and micronutrients, including their classification, function, and sources. The fourth part of the questionnaire measures knowledge of sports nutrition, including the need for macronutrients, hydration, and food choices before, during, and after exercise. Also, the nutritional knowledge scoring system was based on the percentage of correct answers to the nutritional knowledge questions by the bodybuilders.

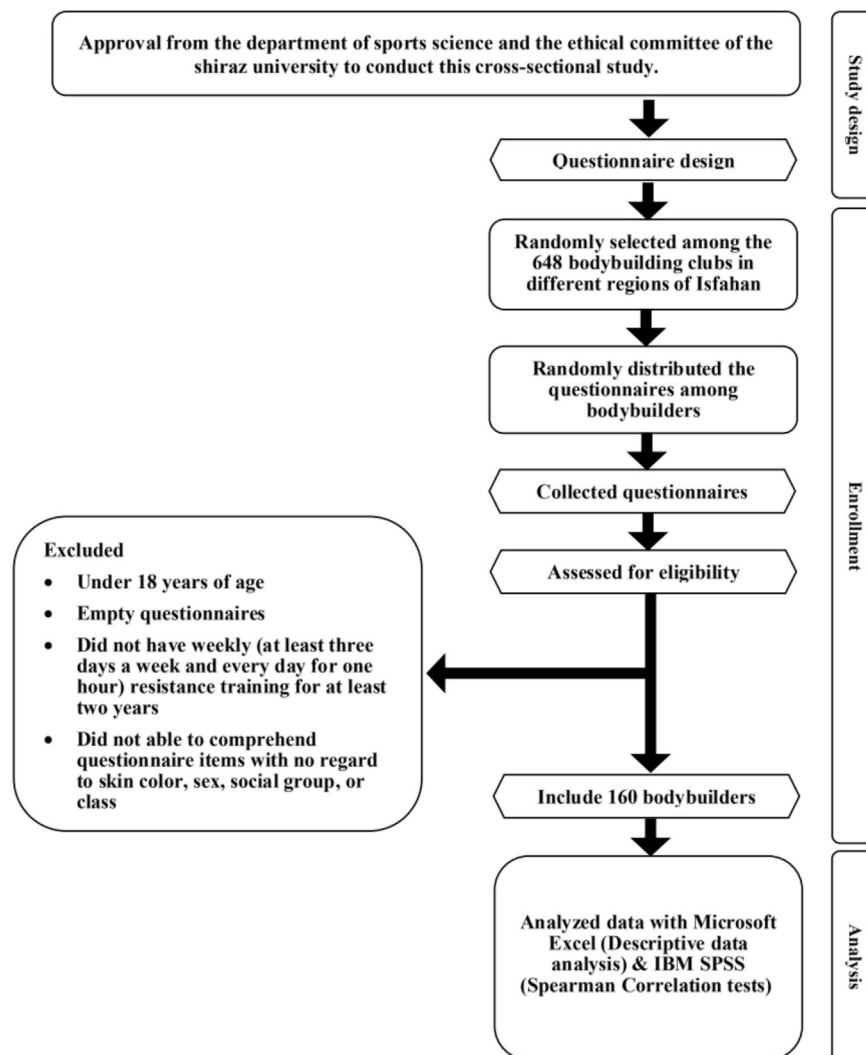


FIGURE 1. Participants flow diagram.

Data analysis

Descriptive data analysis was performed with Microsoft Excel 365 (2019) and was obtained for all variables. IBM SPSS Statistics 26.0.0.0 was used to perform Spearman correlation tests to check the relationship between variables (95% confidence levels and the level of significance was set at a value of ≤ 0.05).

Results

Subjects

A total of 160 bodybuilders (52.5% males and 47.5% females) were included in the analysis, and participants' characteristics are presented in Table 1.

DS intake

The data indicate that 56.2% of all bodybuilders were classified as regular DS consumers because they consumed ≥ 1 supplement weekly. The most common DS used by bodybuilders were vitamin C (56.2%), vitamin D (51.2%), and whey protein (45.6%). The table also highlights the popularity of some specific categories, such as immune system stimulators (for example, omega-3, zinc) and weight loss supplements (for example,

caffeine, L-carnitine). However, to avoid redundancy, the full details on the prevalence of these other supplement types can be found in Table 2.

Micronutrients supplements

The 3 most common micronutrient supplements were vitamin C (56.2%), vitamin D (51.2%), and zinc (39.3%) (Table 3).

Information sources

The most important sources of information for bodybuilders regarding DS were fitness trainers/coaches (35.6%) and registered dietitians/nutritionists (34.3%). Then, physicians with 8.7%, the internet and social media, magazines, academic books, advertising brochures, and DS stores with 2.5%, friends and training partners with 1.8%, and newspapers and other media with 0.6% are assigned. It should be mentioned that 4.3% of bodybuilders did not use DS, and 2.5% used other methods to get information about DS (Table 4).

DS sources

Drugstores were the largest source for buying DS (36.7%), followed by trainers (19.3%), representatives of manufacturing

TABLE 1
Subject characteristics as percent and frequency (n) of the study population.

	Frequency	Percent
Gender		
Male	84	52.5
Female	76	47.5
Age group (y)		
18–25	39	24.3
26–30	56	35
31–35	34	21.2
36–40	17	10.7
>40	14	8.8
Level of education		
Diploma and below	26	16.2
Bachelor's degree	78	48.8
Masters	43	26.9
PhD	13	8.1
Bodybuilding history (y)		
2–4	44	27.5
5–10	68	42.5
>10	48	30
Training frequency (wk ⁻¹)		
3–4	70	43.7
5–6	59	36.9
7	31	19.4
Nutrition course		
Yes	96	60
No	64	40

companies (16.2%), online stores (10%), registered dietitians/nutritionists (7.5%), fitness clubs (6.8%), and retailers (0.6%). Of course, 10% of bodybuilders used other methods to prepare their DS (Table 5).

Reasons for DS intake and not using them

The 3 most important reasons to take DS were increasing performance (54.3%), increasing the need for DS through exercise (53.6%), and preventing injury and improving recovery (36.2%). The 3 most important reasons not to take DS were that if you consume a balanced diet, there is no need to use DS (68.1%); the use of protein supplements can cause liver and kidney damage (36.3%); and I do not believe in DS and consider them ineffective and mostly a business (27.2%) (Table 6).

Dietary supplement's side effects

Considering that out of 160 bodybuilders who answered the questionnaire, 22 did not use DS at all; the statistical population of this question is 138 people. The most common side effects caused by the use of DS are, respectively, skin problems such as skin rashes (21%), increased liver enzymes (10.8%), hair loss (9.4%), increased blood pressure and or heart palpitations (8.6%), anxiety and insomnia, lack of proper rest, abdominal cramps, and digestive problems such as bloating, constipation (5.7%), headaches, and nausea (5%), abnormalities sexual issues such as irregular menstruation, polycystic ovary syndrome, decreased sexual desire, kidney pain (2.8%), proteinuria (excretion of protein in the urine), increased facial and body hair (1.8%), hoarseness in males or hoarseness of voice in females (1.2%), and kidney stones (0.7%). Of course, it should be noted that 60.8% of bodybuilders did not experience any side effects. All of these results are reported in Table 7.

TABLE 2
Intake of dietary supplements among participants.

	Frequency	Percent
Soy protein	14	8.75
casein	33	20.62
Creatine monohydrate	37	23.12
Whey protein	73	45.62
Red meat protein	32	20
Egg white protein (albumin)	57	35.62
BCAA	54	33.75
Beta-alanine	21	13.12
Lucien	11	6.87
Glutamine	43	26.87
Amino	29	18.12
Arginine	37	23.12
HMB	19	11.87
Co-enzyme Q10	7	4.37
Inosine	0	0
Ginseng	22	13.75
Bee pollen	4	2.5
Hydroxy methyl butyrate	4	2.5
Selenium	7	4.37
Zink	54	33.75
Omega-3	72	45
Vitamin D	80	50
Others	3	1.87
L-Carnitine	27	16.87
Ephedra	4	2.5
caffeine	55	34.37
Green coffee beans	7	4.37
CLA	9	5.62
DHEA	2	1.25
Green tea extract	25	15.62
Others	12	7.5
Nothing	77	48.12

Abbreviations: BCAA, branched-chain amino acid; CLA, conjugated linoleic acid; DHEA, dehydroepiandrosterone; HMB, hydroxy methyl butyrate.

The relationship between the use of DSs and other research variables

The results showed that 33.1% of male and 15.2% of female bodybuilders used DSs. The results indicated a significant

TABLE 3
Prevalence of using micronutrient supplements among bodybuilders.

	Frequency	Percent
Vitamin K	17	10.62
Vitamin E	55	34.37
Vitamin A	19	11.87
Vitamin D	82	51.25
Vitamin C	90	56.25
Vitamin B-1	37	23.12
Vitamin B-2	15	9.37
Vitamin B-5	14	8.75
Vitamin B-6	22	13.75
Vitamin B-9	26	16.25
Vitamin B-12	23	14.58
Multi-vitamin mineral	58	36.25
Phosphorate	3	1.87
Magnesium	48	30
Calcium	58	36.25
Zinc	63	39.37
Iron	36	22.5
Potassium	14	8.75
Nothing	14	8.75

TABLE 4
Dietary supplements information sources among bodybuilders.

	Frequency	Percent
Fitness trainers/coaches	57	35.62
Registered dietitian/nutritionist	55	34.37
Friends and teammates	3	1.87
Physician	14	8.75
Internet and social media	4	2.5
Academic magazines, books, and advertising brochures	4	2.5
Dietary supplements store	4	2.5
Newspaper	1	0.62
without consultation	7	4.37
Others	4	2.5

TABLE 5
Sources where athletes buy DS among bodybuilders.

	Frequency	Percent
Online shops	16	10
Trainer/coach	31	19.37
Drugstore	102	63.75
Gym	11	6.87
Registered dietitian/nutritionist	12	7.5
Companies' represent	26	16.25
Retailers	1	0.62
Others	16	10

TABLE 6
Reasons for dietary supplement use and non-use among bodybuilders.

	Frequency	Percent
Increase performance	75	54.34
Increased need for DS as a result of exercise	74	53.62
They are harmless	20	14.49
The pressure of teammates and the encouragement of friends and coaches	3	2.17
Eliminate stress and create a sense of victory	6	4.34
Prevent injury and improve recovery	50	36.23
Physical and muscular appearance	17	12.31
A substitute for daily food	2	1.44
The need for DS for all successful athletes	22	15.94
Appetite control and fat mass reduction	16	11.59
Boosting the immune system	33	23.91
Increasing self-esteem and creating a pleasant feeling	11	7.97
Improve health	45	32.60
Dietary supplements are a form of performance-enhancing drugs and are considered doping	2	9.09
If you consume a balanced diet, there is no need to use dietary supplements	15	68.18
I cannot afford to use Dietary supplements due to their high cost	1	4.54
I do not believe in dietary supplements; I consider them ineffective and mostly a business	6	27.27
The use of protein supplements can cause liver and kidney damage	8	36.36

Abbreviation: DS, dietary supplement.

relationship between gender and DS used ($P = 0.001$, $r = 0.330$). The percentage of bodybuilders using DS varied across different age groups: 25.3% for 18–25 y, 36.0% for 26–30 y, 25.2% for 31–35 y, 35.7% for 36–40 y, and 17.5% for over 40 y, with no significant relationship between age and supplement use ($P = 0.332$; $r = 0.077$). Regarding educational background, 27.7% of

TABLE 7
Dietary supplement's side effects.

Side effects	Percentage of changes
Skin rashes	21.01
Liver enzymes	10.86
Hair loss	9.42
Blood pressure or heart palpitations	8.69
Constipation	5.79
Headaches and nausea	5.07
Kidney pain	2.89
Facial and body hair	1.87
Hoarseness in men or hoarseness of voice in females	1.25
Kidney stones	0.72

bodybuilders with a diploma or lower education, 21.3% with a bachelor's degree, 28.6% with a master's degree, and 33.3% with a doctorate consumed DSs. Nevertheless, there was no significant relationship between DS use and educational level ($P = 0.262$; $r = 0.089$). Additionally, the results showed that 18.3% of bodybuilders with 2–4 y of experience, 23.7% with 5–10 y of experience, and 31.2% with over 10 y of experience consumed DSs. A significant relationship was found between bodybuilding history and DS consumption ($P = 0.045$; $r = 0.158$). Furthermore, 25.8% of bodybuilders participated in nutrition courses, and 22.7% of those who did not use DSs. There was no significant relationship between participating in nutrition courses and DS consumption ($P = 0.161$, $r = 0.111$). Moreover, 19.9% of bodybuilders who exercise 3–4 d/wk, 29.3% with 5–6 d exercising/wk, and 26.2% who exercise every day/wk consumed DSs. There was a significant relationship between the number of weekly exercise sessions and DS consumption ($P = 0.050$, $r = 0.156$). Finally, no significant relationship was found between DS use and nutrition knowledge ($P = 0.534$, $r = -0.050$). All of these results can be found in [Table 8](#).

Nutritional knowledge

The number of questions related to testing carbohydrate nutritional knowledge was 10, with 971 correct answers out of 1600 questions, equaling 60.6% accuracy. Also, the number of questions related to checking fats' nutritional knowledge was 7, with 661 correct answers out of 1120 questions, equaling 59% accuracy. In addition, the number of questions related to checking proteins' nutritional knowledge was 7, with 675 correct answers out of 1120 questions, equaling 60.2% accuracy. Altogether, the level of nutritional knowledge regarding macronutrients was 60.07%. Additionally, the number of questions related to checking micronutrient nutritional knowledge was 11, with 1168 correct answers out of 1760 questions, equaling 66.3% accuracy. Also, 13 questions related to checking sports nutrition nutritional knowledge were asked, with 1030 correct answers out of 2080 questions, equaling 49.5% accuracy. Overall, the number of questions related to examining the level of total nutritional knowledge was 48, with 4505 correct answers out of 7608 questions, equaling 58.6% accuracy.

Nutrition source information

The registered dietitian/nutritionist was the most important source of nutrition information for bodybuilders (58.1%), followed by the trainer (51.8%) ([Table 9](#)).

TABLE 8
Spearman's correlation between the using dietary supplements (DSs) and the variables.

			Using DS
Spearman's rho	Gender	<i>r</i>	0.330
		Sig. (2-tailed)	0.000
		<i>N</i>	160
Age		<i>r</i>	0.077
		Sig. (2-tailed)	0.332
		<i>N</i>	160
Educational level		<i>r</i>	0.089
		Sig. (2-tailed)	0.262
		<i>N</i>	160
Bodybuilding history		<i>r</i>	0.158
		Sig. (2-tailed)	0.045
		<i>N</i>	160
Nutrition courses		<i>r</i>	0.111
		Sig. (2-tailed)	0.161
		<i>N</i>	160
The number of exercise sessions		<i>r</i>	0.156
		Sig. (2-tailed)	0.050
		<i>N</i>	160
Nutrition knowledge		<i>r</i>	-0.050
		Sig. (2-tailed)	0.534
		<i>N</i>	160

Abbreviations: *N*, number of participants; *r*, correlation coefficient; *Sig.*, significance.

The relationship between nutritional knowledge and other research variables

The nutrition knowledge of male bodybuilders was 60%, and the nutrition knowledge of female bodybuilders was 57%. The results indicated no significant relationship between gender and nutritional knowledge ($P = 0.151$, $r = -0.114$). Nutritional knowledge of bodybuilders with diplomas and lower degrees was 54.8%, a bachelor's degree was 58.7%, a master's degree was 55.4%, and a doctorate was 65.7%. There was no significant relationship between nutritional knowledge and educational level ($P = 0.057$, $r = 0.151$). The average nutritional knowledge of bodybuilders with 2–4 y of experience was 52.3%; with 5–10 y of experience, 59.3%; and with >10 y of experience, 63.4%. So, a significant relationship existed between bodybuilding history and nutritional knowledge ($P = 0.001$, $r = 0.264$). The nutrition knowledge of bodybuilders who participated in the nutrition courses was 63.1%, and the nutritional knowledge of those who did not participate in the nutrition courses was 51.7%. Moreover, there was a significant relationship between the nutritional knowledge of the bodybuilders and participation in nutrition courses ($P = 0.000$, $r = 0.384$) (Table 10).

TABLE 9
Nutritional information sources among bodybuilders.

	Frequency	Percent
Registered dietitian/nutritionist	93	58.1
Friends and teammates	23	14.37
Internet and social media	48	30
Trainer/coach	83	51.87
No plan	15	9.37
Others	38	23.75

Discussion

This study aimed to investigate the level of nutritional knowledge, prevalence, and consequences of consuming DS among bodybuilders in Iran. In this study, 56.25% of bodybuilders consumed ≥ 1 DS, and the prevalence of DS used varied between other studies: 100% [12], 84.7% [19], 81.31% [20], 76.9% [21], 64.7% [23], 64% [24], 43.8% [9,25], 38.2% [26], and 36.8% [27]. Depending on different prevalence, definitions, and criteria among studies, this study asked bodybuilders about their consumption of DS in the last 4 wk [43,44]. The prevalence of DS intake usually increases when focusing on longer timeframes [44,45]. The stated prevalence rates could vary depending on factors such as sociodemographic and cultural characteristics, the type of gyms included, or methodological considerations such as what was perceived as a DS and the methods of data collection [9]. Except for a few studies [46–48], males generally consumed more DS than females [25,26,49,50], which is consistent with this study. DS use among athletes varies depending on gender, with male athletes being more likely to consume DS and use it for specific goals like muscle gain or performance improvement. In contrast, female athletes are more likely to take DS for their health, recovery, or because of an inadequate diet [51,52]. Additionally, a few studies observed that older athletes consumed more DS than younger ones [49], whereas this study revealed no significant relationship between age and DS use. The prevalence of DS use may vary depending on the training objectives of the various age groups, such as a younger age group's greater emphasis on strength and muscle mass and an older age group's greater emphasis on health [20, 53]. In addition, there was no significant relationship between DS consumption and educational level in this study; nevertheless, Baltazar-Martins et al. [24] showed the opposite result. Although there is limited information on the relationship between educational level and DS use, a higher educational level may affect DS use among athletes. Because they pay more attention to their health and have more information, according to Lacerda et al. [23], Ruano and Teixeira [25], and Molz et al. [50], DS use was higher among those with more prolonged exercise habits and who exercised more, which is in line with the

TABLE 10
Spearman's correlation between nutritional knowledge and the variables.

			Nutritional knowledge
Spearman's rho	Gender	<i>r</i>	-0.114
		Sig. (2-tailed)	0.151
		<i>N</i>	160
Educational level		<i>r</i>	0.151
		Sig. (2-tailed)	0.057
		<i>N</i>	160
Bodybuilding history		<i>r</i>	0.264
		Sig. (2-tailed)	0.001
		<i>N</i>	160
Nutrition courses		<i>r</i>	0.384
		Sig. (2-tailed)	0.000
		<i>N</i>	160

Abbreviations: *N*, number of participants; *r*, correlation coefficient; *Sig.*, significance.

current findings. Athletes who train more often take more DS because of greater need and lack of time to meet their needs. Although Montuori et al. [20] demonstrated that individuals with a higher nutrition knowledge score are more likely to take DS, findings from this study did not confirm a significant relationship between them. Although this study did not confirm the relationship, people with more nutritional knowledge may consume more or less DS depending on the conditions because they consume DS according to their needs and awareness.

Numerous studies indicate the inadequate nutrition knowledge of athletes [54–57]. Finamore et al. [28] also discovered that only 47.3% of respondents had adequate nutrition knowledge of the sport, and the nutrition knowledge rate was 57.1%, which is close to this study. Considering the importance of nutrition knowledge in choosing food and DS, athletes' high levels of nutrition knowledge can play a critical role in their health and performance. Unfortunately, most studies report that athletes' nutritional knowledge is poor, and planning to increase athletes' nutritional knowledge is essential. In this study, the average nutritional knowledge of male bodybuilders (60%) was higher than that of female bodybuilders (57%). According to Finamore et al. [28] and Ozdoğan et al. [55], males had higher nutrition knowledge than females. Smith-Rockwell et al. [29] showed that males had lower nutrition knowledge than females because, in several countries and also religions, females have restrictions on participating in bodybuilding, and also because of the different status of training programs for people, there may be differences between the nutritional knowledge of male and female bodybuilders. However, no specific conclusion can be reached. This study showed that nutritional knowledge regarding protein (60.2%) was lower than micronutrients (66.3%). Jovanov et al. [10] demonstrated that <40% of athletes knew the proper and intended use of protein, creatine, amino acids, beta-alanine, and glutamine. At the same time, they had a greater understanding of vitamins and minerals, sports drinks, and caffeine. Jovanov et al.'s findings are consistent with this study's results. According to the studies and media advertisements, nutritional knowledge regarding protein is more significant than other things, but reaching a general conclusion is impossible.

In this study, vitamin C (56.2%), vitamin D (51.2%), and whey protein (45.6%) were the most frequently used DS by athletes. According to Baltazar-Martins et al. [24], proteins and DS containing amino acids, or branched-chain amino acids (BCAAs), were the 2 most frequently used DS. Additionally, Khoury and Antoine-Jonville [38], Goston and Correia [27], Oliver et al. [30], Lacerda et al. [23], and Ruano and Teixeira [25] all found that the most commonly ingested types of DS were proteins and amino acids, which are roughly the same as another study that found that whey protein (96%), BCAAs (94%), and creatine (85%) were the most common DS [12]. Moreover, Morrison et al. [19] found different results in another study, indicating that many participants consumed multivitamins and minerals, protein shakes or bars, vitamin C, and vitamin E ≥ 5 times/wk. Another study demonstrated that protein supplements, multivitamins, BCAAs, caffeine, and creatine were the most commonly used DS [9]. Therefore, as this study indicates that whey protein is the third most commonly used DS, several other studies have shown that protein and amino acid supplements are among athletes' most commonly used DS. However,

other studies rarely mentioned vitamin D as a supplement, whereas 1 study mentioned vitamin C frequently. This finding can be explained by the importance of consuming adequate protein for building muscle [58] and bringing bodybuilders closer to their goals.

In this study, the most important information sources for bodybuilders regarding DS were trainers or coaches (35.6%) and registered dietitians/nutritionists (34.3%), and regarding nutrition was the registered dietitian/nutritionist (58.1%), followed by the trainer (51.8%). This finding is consistent with the results of research conducted by Denham [31] and a study by Nabuco et al. [32], which demonstrated that the most prevalent source of information among Brazilian competitive athletes was trainers. These results were inconsistent with the outcomes of Aljaloud and Ibrahim [33] in Saudi Arabia and Silva et al. [21] in Sri Lanka in which the most common source of information correlated with DS among participants was from a medical doctor. Moreover, another research demonstrated that high amounts of elite Spanish athletes got information related to the DS themselves and did not look for professional consults [24]. Also, it is worth mentioning that a study showed that 66.8% of the resistance training and bodybuilding participants utilized DS without receiving advice from a qualified professional [21]. Trainers with little knowledge, rather than registered dietitians/nutritionists, significantly impact the transfer of nutritional information to athletes, leading to misinformation among bodybuilders. According to the newly implemented training programs and policies, the contribution of registered dietitians/nutritionists in transferring nutritional information to athletes has increased compared with before. However, the involvement of registered dietitians/nutritionists is still low and should be increased.

In this study, pharmacies and trainers were the most common sources for purchasing DS. However, Baltazar-Martins et al. [24] found that most athletes purchased DS from a store, while Ruano and Teixeira [25] found that the internet (56.2%) was the most common source for purchasing DS. Additionally, Jovanov et al. [10] demonstrated that athletes generally buy DS through specialized retail stores (59.1%), and the 3 studies mentioned are inconsistent with this research. Another study conducted by Muwonge et al. [35] found that registered dietitians/nutritionists, retail stores, and pharmacies were the 3 most popular places to purchase DS. Moreover, Finamore et al. [28] showed that specialized sports nutrition stores (36.6%), pharmacies (31.7%), and online (27.1%) were the most common sources for buying DS. This study, like Finamore et al. [28] and Muwonge et al. [35], shows pharmacies as a common source of DS purchases. It is suggested that rules be enacted requiring the purchase of DS only from specific centers, such as pharmacies or certain websites, and that a license from registered dietitians/nutritionists be required.

In this study, bodybuilders use DS for 3 main reasons: to increase the performance of athletes, to address the increased need for DS because of sports, to prevent injury, and to improve recovery. In a meta-analysis study, Daher et al. [49] identified the most common reasons as improving athletic performance, health, and recovery. Moreover, Barrack et al. [46] indicated that the predominant reasons for DS use included increasing strength/power and muscle mass in males and enhancing health in females [44,46]. Additionally, Jovanov et al. [10]

demonstrated that enhancing athletic performance (19%) in males and promoting health (18%) in females were the primary motivations for DS use [10,57]. Sánchez-Oliver et al. [12] found that improving sports performance (81.2%) and physique (43.7%) are the 2 main reasons for using DS. Ruano and Teixeira [25] demonstrated that the main reasons for using DS included gaining muscle (55.7%), accelerating recovery (52.7%), and enhancing performance (47.3%). As mentioned, enhancing performance is a primary motivation for using DS among athletes in this and other studies. Specific DS may be required considering the bodybuilder's health status and sports stage. However, bodybuilders usually take DS to increase muscle mass and improve recovery. Avoiding excessive and unnecessary consumption of DS is crucial.

In this study, the most common side effects caused by the use of DS were skin problems such as skin rashes (21%), increased liver enzymes (10.8%), and hair loss (9.4%). Individuals involved in bodybuilding have a notably high frequency of DS usage, exposing them to significant health risks [12,21,43]. In other studies, these health risks include kidney damage [59], severe cholestasis [60], and liver damage [61] that are not in line with this study. Despite the general safety of most DS at recommended doses, athletes must be aware of the potential risks associated with DS use. Along with risks of overdosing and the potential for unintentional interactions when taking multiple DS simultaneously, there is also a chance of accidental or intentional contamination with stimulants, estrogenic substances, diuretics, or anabolic agents [62]. The side effects of using DS can be related to the DS itself or contamination of the DS. To avoid side effects caused by taking DS, standard DS should be used at the recommended dosage.

It is essential to acknowledge the limitations of our investigation. One limitation is the use of self-reported responses, which may affect the reliability of the responses. Additionally, the measured variables depended on participants' beliefs, which may not accurately represent reality. Because of the conditions of COVID-19, full supervision of the researcher was not possible. Consequently, the subjects may have sought assistance from other sources, like friends or the internet.

In conclusion, this study concluded that bodybuilders' most common information sources were coaches and registered dietitians/nutritionists. This study found moderate nutrition knowledge among bodybuilders, which can lead to mistakes in choosing the best DS and diet that meet their unique needs. Skin problems such as skin rashes, increased liver enzymes, and hair loss were the most adverse side effects that bodybuilders experienced. The most common DS used by bodybuilders were vitamin C, vitamin D, and whey protein, mostly purchased from drugstores and trainers. Increasing performance, increasing the need for DS through exercise, preventing injury, and improving recovery were the most important reasons for taking DS. This study demonstrated that gender, bodybuilding history, and the number of weekly exercise sessions had a significant relationship with the prevalence of DS. To increase the nutritional knowledge of athletes and the correct use of DS, it is necessary to have a sports dietitian/nutritionist in gyms.

Author contributions

The authors' responsibilities were as follows – YB, FD, MH: conceptualization; YB, ZJ, KS, NJ: methodology; YB, ZJ, NJ:

software; MH, FD, KS: formal analysis; NJ, MH, BI, YB: writing—original draft preparation; ZJ, KS, FD: visualization; YB, ZJ, NJ, BI, MH, KS: writing—review and editing; MH: supervision; and all authors: read and approved the final manuscript.

Conflict of interest

The authors declare no competing interests.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the Human Research Ethics Committee of Shiraz University, Shiraz, Iran (ethics approval code: IR.SUMS.REHAB.REC.1399.10). Informed consent was obtained from all individual participants included in the study.

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Data availability

The datasets used and/or analyzed in this study are available from the corresponding author on reasonable request.

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