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Patterns of Nutritional Supplement Use in Turkish Handball Players: Influence of Sex and Competition Level Based on the AIS Classification System

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Abstract

Handball is a sport that demands explosive movements and unique skills, and its popularity has been rising in recent years. This study evaluated elite handball players' nutritional supplement (NS) use profiles and the differences in sex, competition level, and competition type based on the Australian Institute of Sport (AIS) criteria. The data collection form contains questions about participants' sociodemographic characteristics, training details, use of supplements, and related factors. Supplements were classified into A, B, C, and D classes according to the scientific evidence level of the AIS. The study involved 92 elite handball athletes, comprising 48 professionals and 44 amateurs, and included 37 females and 55 males. The most frequently used supplements among participants were magnesium (37.0%) (Group C—AIS), vitamin C (20.7%) (Group B—AIS), whey protein (19.6%), sports bars (19.6%), and vitamin D (19.6%) (Group A—AIS). Regarding sex differences, a significant difference was observed only in Group C supplements, with male players using them more frequently than female players ($p < 0.05$). Professional athletes exhibited a significantly higher prevalence of supplement use, covering total, Group A, sports foods, performance supplements, and Groups B and C, relative to amateur players ($p < 0.05$). The results reveal that handball players have limited awareness of NS, emphasizing the need for training and consulting services.

Keywords: handball; sex; sport; supplement; nutrition; Australian Institute of Sport (AIS)

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1. Introduction

With more than 19 million players worldwide, handball is one of Europe's most popular team sports [1]. As an intermittent team sport, handball demands repeated, brief episodes of high-intensity exertion interspersed with lower-intensity movements [2]. While the physical demands can be position-dependent [3], key determinants of performance across all players include explosive actions like acceleration, deceleration, sprinting, changes-of-direction, jumps, and shots [4]. Players can relax off the court because they may alternate as often as they like. Thanks to this feature, elite players can adopt various

offensive and defensive roles, which also makes the action more intense. The ability to make physical contact while playing is one of the unique features of handball. Attackers trying to fire can be stopped and disrupted by defenders. While this happens, attacking players constantly interact with defenders to open space for their teammates or put themselves in advantageous scoring positions [5,6]. Therefore, players must possess high levels of muscle strength in performance for certain positions [6].

Handball is a sport that involves high-intensity, explosive offensive and defensive movements, such as jumping and running, as well as sport-specific actions like throwing, catching, and blocking. Elite team handball is a physically demanding intermittent team sport, where players are exposed to high relative workloads with substantial estimated aerobic energy expenditure interspersed by short periods of dominant anaerobic energy production as reflected by the limited amount of high-intensity running [3,4]. The position of a player on the court affects the physical demands of handball. Nonetheless, crucial motions like sprinting, jumping, shooting, changing directions, acceleration, and deceleration are necessary for overall sport performance [7,8]. Competitive handball players need a mix of technical, tactical, physical, and psychological aspects to deliver excellent performance during matches [9]. Therefore, physical ability in handball is characterized by agility, high acceleration, strong jumping capacity, and significant power and force outputs in both the upper and lower body [6,10].

During a match, an elite handball player typically moves 4370 ± 702.0 m, about 80% of that distance spent walking (35.0 ± 6.94%) or standing immobile (43.0 ± 9.27%). Meeting these high physiological demands requires the athlete to be in excellent physical condition [6]. Professional handball players must also develop and maximize muscle strength, agility, speed, and endurance [8]. In this context, handballers must have an optimal nutrition program to obtain balance and adequate nutrients. Proper nutrition helps maintain physical and cognitive performance, supports injury prevention, accelerates return to play, optimizes training adaptations, and accelerates recovery [11]. When a dietary program fails to meet nutritional needs, supplements can enhance athletes' performance and recovery.

Athletes widely use nutritional supplements (NS) to enhance physical performance or provide health benefits, depending on sex, competition level, and competition type [12,13]. It has been reported that handball players also frequently use NS to facilitate the achievement of their nutritional goals [14,15]. Although generally low-risk, certain NS can cause toxicity or adverse effects due to unregulated products with questionable ingredients and quality. Moreover, some NS have been found to contain substances that are prohibited in sports or have been linked to significant morbidity and mortality. The Australian Institute of Sport (AIS) uses scientific evidence and practical guidelines to assess sports supplements. Based on these evaluations, NS are categorized into four main groups within the ABCD Classification System, which considers their safety, permissibility, and effectiveness [16].

While handball players commonly use NS to support their dietary goals [15], there is a lack of studies examining this practice and related parameters among Turkish players according to international standards. The primary objective of this study was to investigate the use of NS among Turkish handball players competing in various competitions based on the AIS classification. Additionally, the study explored the relationship between NS use and several demographic and performance-related variables. It examined NS utilization among athletes, considering sex (male/female) and competition level (professional vs. amateur). In addition, an evaluation was conducted according to the type of competition (national vs. international athletes) to identify supporting evidence.

The following hypotheses were tested:

H1: *The use of NS among Turkish handball athletes is common.*

H2: *Male handball players use NS more frequently than females.*

H3: *Handball players in professional competitions utilize NS more than those in amateur competitions.*

H4 (Additional Hypothesis): *Athletes competing internationally use more NS than those competing nationally.*

2. Materials and Methods

2.1. Study Design

This cross-sectional research utilized convenience sampling to evaluate the use of NS among licensed male and female handball players from various competitions in Türkiye. The inclusion criteria comprised being a Turkish citizen over 12 years of age, holding a valid handball license, being in good health, and consenting to participate. Ninety-two handball players participated, comprising 55 male and 37 female handball players in Türkiye, including professional competitions (Super Competition, 1st Competition, 2nd Competition) with 48 players, and amateur competitions (Youth Status and Regional Competition) with 44 players.

A data collection form was utilized to assess the athletes' NS consumption. Initially, coaches were contacted with the support of the Turkish Handball Federation. The form was distributed by the coaches of the respective handball clubs through face-to-face and online interviews. For individuals under 18, the form was primarily completed through face-to-face interviews to minimize bias and errors. Information regarding these supplementation protocols was also collected during the survey.

According to data from the Turkish Handball Federation's website, the number of licensed handball players in the 2023–2024 season was 23,666, while the figures for the 2024–2025 season had not yet been reported [17]. Based on a 95% confidence interval and assuming an unknown population size, the target sample size was determined as 384 athletes. During the season, coaches of all handball teams were contacted, and athletes who provided informed consent were voluntarily recruited. However, the target population could not be reached due to limited athlete availability and voluntary participation, and the final sample consisted of 92 players. This sample corresponded to a confidence interval of 0.1, a standard error of 0.05, and a relative standard error of 10.46. Sample size power analysis was performed using the Australian Bureau of Statistics Sample Size Calculator [18].

The study was conducted in accordance with the Declaration of Helsinki and approved by the Scientific Research and Publication Ethics Committee of Istanbul Health and Technology University (protocol code 2025/01-01; date of approval: 8 January 2025).

2.2. Data Collection Form

The data collection form was designed to evaluate athletes' NS consumption patterns. This form has been utilized by various groups, including national and international fencing athletes, professional and amateur rugby players, semi-professional handball players, national and international swimmers, national and international squash players, professional and amateur football players, semi-professional football players, mountain runners, open water swimmers, national marathon runners, national bodybuilders, international rowers, elite sailors, triathlons, and windsurfers [12,13,19–29]. Knapik et al. confirmed the suitability of the survey instrument in a systematic review, where they assessed its methodological quality across eight-domain scoring. These criteria included sampling method, sampling framework, measurement tools, response rate, bias, statistical

presentation, and description of the participant sample. Considering all these features, the use of this form was determined to be appropriate, and the methodological quality rating was determined to be 54% [30].

The survey form was structured into three sections to obtain comprehensive data from handball players. The first section collected demographic characteristics, including age, height, weight, and educational background, to describe the general profile of the participants. The second section focused on sport and training variables, such as the competition level of participation, the highest competitive level achieved, the number of weekly training sessions, and the average duration. These items were designed to assess the athletes' training load and competitive background.

The third section addressed the NS use properties. This part included questions regarding athletes' awareness of legal regulations, previous and current supplement use, the types, timing, and frequency of consumption, and the primary purposes for using NS. Furthermore, it investigated the sources from which supplements were obtained and the individuals or institutions influencing purchasing decisions. This section aims to provide a detailed understanding of NS consumption patterns and their underlying determinants among handball players.

Reported supplements were categorized according to the classification system recommended by the AIS. This system classifies supplements into four groups based on the level of scientific evidence supporting their use. Group A supplements have the highest level of scientific evidence and are divided into three subcategories. In this context, Sports Food includes sports drinks, gels, candy, bars, electrolyte supplements, isolated protein supplements, and combined macronutrient supplements. Medical Supplements comprise iron, calcium, vitamin D, folate, and zinc. Performance Supplements include caffeine, β-alanine, dietary nitrates (such as beetroot juice), sodium bicarbonate, creatine monohydrate, and glycerol. Group B supplements have emerging scientific evidence, though they require further research. This group includes fruit-derived polyphenols, N-acetylcysteine, menthol, pickle juice, vitamin C, quinine, collagen, ketones, curcumin, fish oil, probiotics, prebiotics, multivitamins, and carnitine. Supplements categorized as Group C do not have enough scientific backing to prove they provide athletes with significant performance or health advantages. Some examples of these supplements are magnesium, vitamin E, alpha-lipoic acid, branched-chain amino acids (BCAAs), phosphate, tyrosine, S-adenosylmethionine, and β-Hydroxy β-methylbutyric acid. Group D supplements are discouraged for use by athletes due to the possibility of containing substances that have a high risk of contamination, which could result in positive doping results. It is important to remember that the classification of supplements can evolve as new scientific findings come to light. This study employs the most recent classification currently available on the AIS website [16].

2.3. Statistical Analysis

Data were analyzed using the Jamovi 2.7.5 statistical program (The Jamovi Project, Sydney, Australia). Basic descriptive statistical methods were used to evaluate the data, including total number, percentage, mean, and standard deviation. Pearson's chi-square analysis and odds ratio was utilized to assess the relationships between categorical variables. Fisher's exact test was applied when the expected value of any cell in the table was less than 5. The Shapiro–Wilk normality test was conducted to evaluate the normality of the data, and the Mann–Whitney U test was used to determine the statistical differences between two groups when the data did not follow a normal distribution.

3. Results

3.1. Participant Characteristics

Among the participants, 68.4% (n = 63) were under the age of 20, 20.7% (n = 19) were between 21 and 25 years old, and 10.9% (n = 10) were aged 26 or older. The sex distribution was 59.8% (n = 55) male and 40.2% (n = 37) female. Regarding educational background, 53.3% (n = 49) of participants had a BSc degree, and 2.2% (n = 2) had an MSc degree. Regarding competition levels, 52.2% (n = 48) participated at the professional level, whereas 47.8% (n = 44) were at the amateur level. Additionally, 73.9% (n = 68) of participants competed nationally, while 26.1% (n = 24) engaged internationally.

Table 1 shows descriptive statistics of the participants' characteristics categorized by sex and competition level.

Table 1. Descriptive data of participants by sex and competition level.

	Sex		**Competition Level**		**Total (n = 92)**
	Female (n = 37)	**Male (n = 55)**	**Amateur (n = 44)**	**Professional (n = 48)**	
Age (years)	17.9 ± 8.7	21.5 ± 7.5	16.7 ± 7.4	23.1 ± 7.7	20.0 ± 8.2
Height (cm)	165 ± 7.4	184 ± 8.5	168 ± 10.2	184 ± 8.8	176.0 ± 12.4
Weight (kg)	57.4 ± 9.1	85.8 ± 13.7	63.4 ± 16.3	84.4 ± 14.1	74.4 ± 18.4
Body Mass Index (kg/m^2)	21.0 ± 2.4	25.2 ± 2.8	22.1 ± 3.5	24.7 ± 2.6	23.3 ± 3.3
Weekly Training Days	5.4 ± 1.9	5.4 ± 3.0	4.0 ± 1.4	6.7 ± 2.7	5.4 ± 2.6

Values are presented as mean ± standard deviation (Mean ± SD).

Data on training frequency revealed that 47.8% (n = 44) of participants train six or more times a week, while 52.2% (n = 48) train five or fewer times a week. Participants trained 5.4 ± 2.6 days per week, indicating a relatively high training frequency. Regarding training duration, it was found that 41.3% (n = 38) of the participants trained for 61 to 90 min, and the same proportion, 41.3% (n = 38), reported training for 91 to 120 min.

3.2. Supplement Consumption Patterns and the Frequency of Supplement Distribution, by Sex and Competition Level

Among the participants, 53.3% (n = 49) reported being knowledgeable about the legal regulations regarding NS use, 31.5% (n = 29) stated that they had no opinion on this matter, and 15.2% (n = 14) indicated that they were not knowledgeable about the regulations. 70.7% of participants (n = 65) reported using at least one type of NS. The proportion of those who continue to use NS was 34.8% (n = 32).

Regarding the distribution of NS use across days, the highest rate was observed on both training and match/competition days (28.3%, n = 26), followed by all days (18.5%, n = 17) and only training days (13.0%, n = 12). When examining the timing of supplement intake, 23.9% (n = 22) reported using NS both before and after exercise, 15.2% (n = 14) used them regardless of timing, and 13.0% (n = 12) consumed them only before exercise.

3.3. Evaluation of Parameters Related to Supplement: Analysis by Sex and Competition Level

The handball players involved in the study primarily used NS for three main reasons: to enhance their performance (62.0%), to maintain their health (47.8%), and to improve their physical appearance (21.7%). The three most common places for buying NS were the internet (46.7%), supplement stores (19.6%), and sports clubs (15.2%). When analyzing the factors that motivated the use of NS, the most significant motivators were coaches (40.2%), self-motivation (34.8%), and friends (23.9%).

Sex significantly influenced several parameters related to supplement use (Figure 1; Table A1). Specifically, men were significantly more likely than women to consume supplements for performance enhancement ($p < 0.05$) and were also significantly more influenced by their coaches and friends ($p < 0.05$). Furthermore, male athletes were uniquely observed to obtain supplements through their clubs ($p < 0.05$).

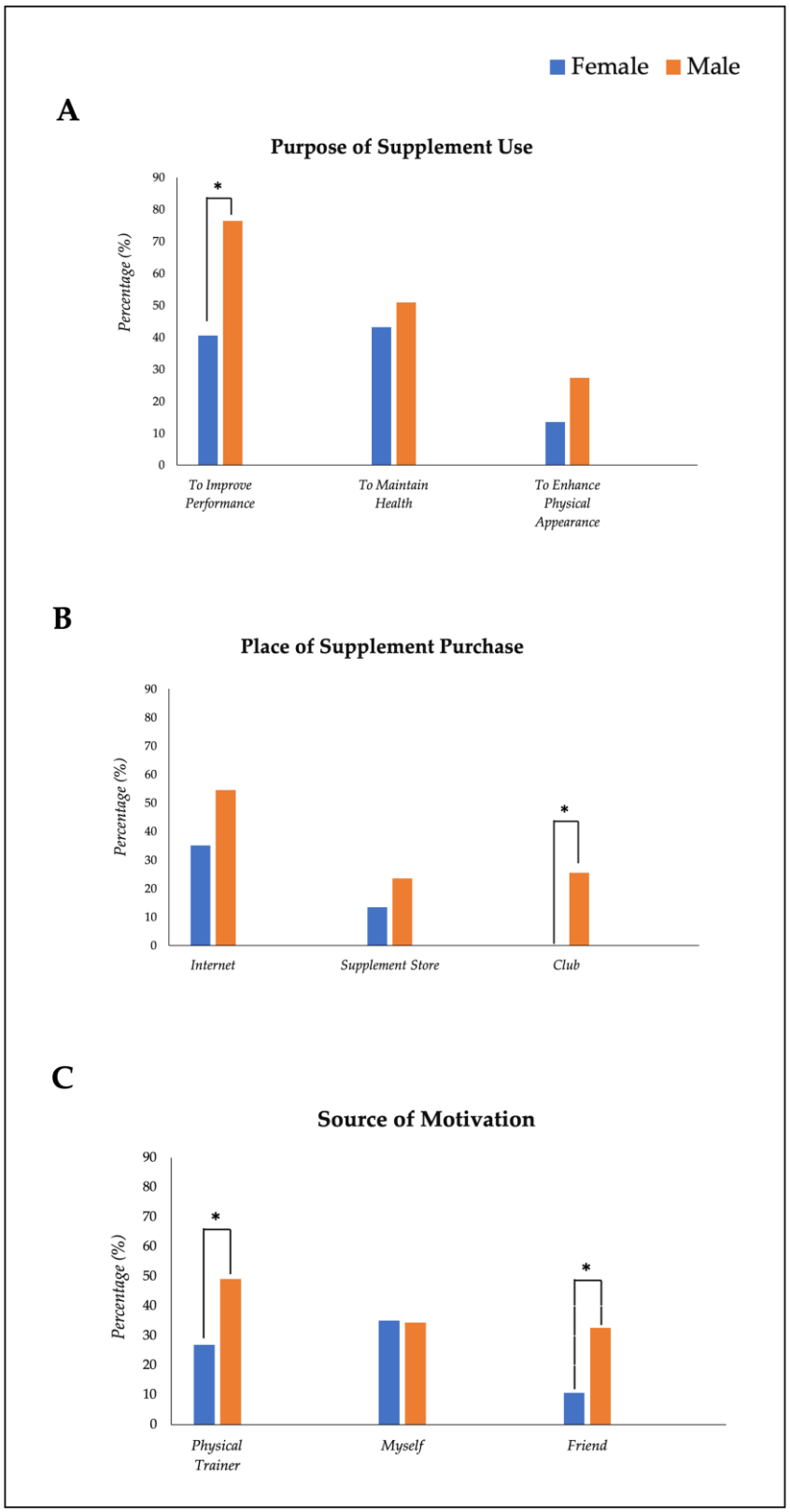

Figure 1. Comparison of parameters related to supplement use by sex. * $p < 0.05$.

Competition level exerted a strong influence on several aspects of supplement use (Figure 2; Table A2). Professional athletes were significantly more likely to use supplements for performance enhancement and were over three times more influenced by their coaches ($p < 0.001$). Furthermore, their acquisition methods differed greatly, with Professionals showing significantly higher usage of both the internet and the sports club as sources ($p < 0.002$).

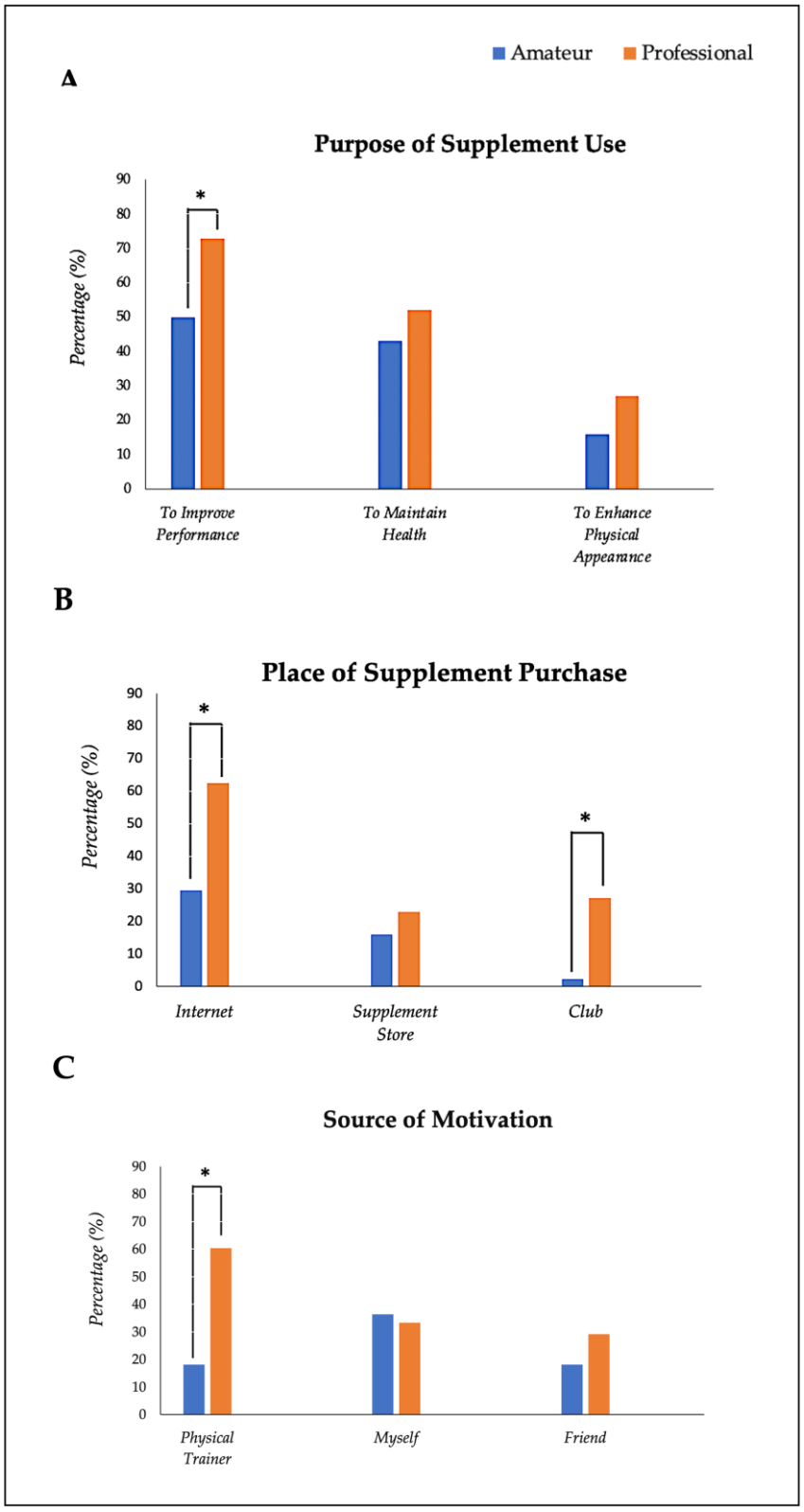

Figure 2. Comparison of parameters related to supplement use by competition level. * $p < 0.05$.

On the other hand, no significant differences were observed in NS use between handball players competing at national and international levels. International players were more likely than national-level players to obtain NS through their clubs (33.3% vs. 8.8%, $p = 0.004$, OR = 5.17 [1.57–17.0]) and to use NS under the motivation of their coaches (62.5% vs. 32.4%, $p = 0.01$, OR = 3.48 [1.32–9.19]) (Table A3).

3.4. The Mostly Used NS by Sex and Competition Level

The most frequently used NS were magnesium (37.0%, $n = 34$), vitamin C (20.7%, $n = 19$), whey protein, sports bars, and vitamin D (19.6%, $n = 18$), sports drinks (18.5%, $n = 17$), omega-3 and caffeine (14.1%, $n = 13$), creatine monohydrate and meat protein (12.0%, $n = 11$), vitamin E and carnitine (8.7%, $n = 8$), pre-workout formulas (7.6%, n = 7), and multivitamin complexes, zinc, iron, and carbohydrate powders (6.5%, $n = 6$).

Sex differences in supplement use were relatively minor, with significant results found only for magnesium and pre-workout formula, both of which were used at a higher prevalence by male athletes (Table 2). In stark contrast, competition level resulted in widespread differences: Professional athletes reported significantly higher use than Amateurs across different supplements, including sports drinks, sports bars, whey protein, carbohydrate powders, creatine monohydrate, vitamin C, and magnesium (Table 2).

Table 2. Comparison of the most frequently used supplements by sex and competition level.

		Nutritional Supplements	Sex					Competition Level				
			Female %	Male %	χ^2	*p* Value	Odds Ratio	Amateur %	Profes. %	χ^2	*p* Value	Odds Ratio
Group A	Sports Foods	Sports Drinks	10.8	23.6	2.42	0.17 FE	2.55 [0.76–8.56]	4.5	31.3	10.9	***0.001*** *,FE	9.55 [2.04–44.7]
		Sports Bar	13.5	23.6	1.44	0.23	1.98 [0.64–6.13]	6.8	31.3	8.71	***0.004*** *,FE	6.21 [1.66–23.3]
		Whey Protein	10.8	25.5	3.01	0.11 FE	2.82 [0.85–9.37]	2.3	35.4	16.0	***<0.001*** *,FE	23.6 [2.98–187]
		Carbohydrate Powders	2.7	9.1	1.48	0.40 FE	3.60 [0.40–32.1]	0	12.5	5.88	***0.03*** *,FE	13.6 [a] [0.74–249]
	Medical Supp.	Meat Protein	13.5	10.9	0.14	0.71	0.78 [0.22–2.78]	9.1	14.6	0.66	0.53 FE	1.71 [0.46–6.29]
		Iron	8.1	5.5	0.26	0.68 FE	0.65 [0.13–3.43]	4.5	8.3	0.54	0.68 FE	1.91 [0.33–11.0]
		Zinc	5.4	7.3	0.13	1.00 FE	1.37 [0.24–7.91]	4.5	8.3	0.54	0.68 FE	1.91 [0.33–11.0]
		Vitamin D	16.2	21.8	0.44	0.51	1.44 [0.49–4.26]	13.6	25.0	1.88	0.17	2.11 [0.72–6.22]
	Performance Supp.	Caffeine	10.8	16.4	0.56	0.55 FE	1.61 [0.46–5.69]	13.6	14.6	0.02	0.90	1.08 [0.33–3.51]
		Creatine Monohydrate	8.1	14.5	0.87	0.52 FE	1.93 [0.48–7.81]	0	22.9	11.5	***<0.001*** *,FE	27.3 [a] [1.56–479]
Group B		Vitamin C	18.9	21.8	0.11	0.74	1.20 [0.42–3.39]	6.8	33.3	9.85	***0.002*** *,FE	6.83 [1.83–25.5]
		Omega-3	8.1	18.2	1.85	0.23 FE	2.52 [0.64–9.86]	6.8	20.8	3.72	0.07 FE	3.60 [0.92–14.1]
		Multivitamin Complex	5.4	7.3	0.13	1.00 FE	1.37 [0.24–7.91]	2.3	10.4	2.50	0.21 FE	5.00 [0.56–44.6]
Group C		Magnesium	24.3	45.5	4.24	***0.04*** *	2.59 [1.03–6.50]	9.1	62.5	28.1	***<0.001*** *	16.7 [5.11–54.4]
		Vitamin E	10.8	7.3	0.35	0.71 FE	0.65 [0.15–2.77]	4.5	12.5	1.83	0.27 FE	3.00 [0.57–15.7]
		Pre-workout Formula	0	12.7	5.10	***0.04*** *,FE	11.6 [a] [0.64–210]	2.3	12.5	3.42	0.11 FE	6.14 [0.71–53.2]

FE = Fisher's Exact Test; [a] Haldane Anscombe correction applied. Pearson's chi-square test was applied for cases not marked with FE. * $p < 0.05$.

3.5. AIS-Based NS Consumption Analysis by Sex and Competition Level

The sex-based analysis of NS use according to the AIS-recommended classification system is given in Table 3. A significant difference between male and female was observed only for Group C supplements. Male handball players reported significantly higher use of Group C supplements than their female counterparts ($p < 0.05$).

Table 3. Number of NS used according to AIS evidence level, by sex.

			Mean	SD	Median	IQR	U Value	z	*p*
	Total Supp. Consumption	Female (*n* = 37)	1.86	2.42	1.00	3.00	829	0.19	0.12
		Male (*n* = 55)	3.18	4.07	1.00	4.00			
Group A	Total Group A	Female (*n* = 37)	1.22	1.58	1.00	2.00	904	0.11	0.34
		Male (*n* = 55)	1.87	2.51	1.00	3.00			
	Sports Foods	Female (*n* = 37)	0.70	1.24	0.00	1.00	898	0.12	0.28
		Male (*n* = 55)	1.18	1.85	0.00	2.00			
	Medical Supplements	Female (*n* = 37)	0.30	0.52	0.00	1.00	977	0.04	0.68
		Male (*n* = 55)	0.35	0.55	0.00	1.00			
	Performance Supplements	Female (*n* = 37)	0.22	0.42	0.00	0.00	930	0.09	0.36
		Male (*n* = 55)	0.35	0.58	0.00	1.00			
	Group B	Female (*n* = 37)	0.35	0.75	0.00	0.00	830	0.18	0.07
		Male (*n* = 55)	0.67	1.04	0.00	1.00			
	Group C	Female (*n* = 37)	0.57	0.96	0.00	1.00	772	0.24	***0.033*** *
		Male (*n* = 55)	1.13	1.64	1.00	1.00			

The Mann–Whitney U test was performed. The z-value represents the effect size; * $p < 0.05$. IQR: Interquartile Range.

The analysis of NS use between amateur and professional athletes, according to the AIS-recommended classification system, is presented in Table 4. Accordingly, professional handball players were found to consume significantly higher amounts of total supplements, Group A supplements, sports foods (subgroup A), performance supplements (subgroup A), and Group B and Group C supplements compared to amateurs ($p < 0.05$).

Table 4. Number of NS used according to AIS evidence level, by competition level.

			Mean	SD	Median	IQR	U Value	z	*p*
Total Supp. Consumption		Amateur	1.11	1.88	0.00	2.00	468	0.37	***<0.001*** *
		Professional	4.06	4.11	3.00	4.50			
Group A	Total Group A	Amateur	0.77	1.31	0.00	1.00	613	0.42	***<0.001*** *
		Professional	2.38	2.56	2.00	3.00			
	Sports Foods	Amateur	0.39	0.87	0.00	0.00	667	0.37	***<0.001*** *
		Professional	1.54	1.97	1.00	3.00			
	Medical Supplements	Amateur	0.23	0.48	0.00	0.00	876	0.17	0.077
		Professional	0.42	0.58	0.00	1.00			
	Performance Supplements	Amateur	0.16	0.43	0.00	0.00	807	0.24	***0.011*** *
		Professional	0.42	0.58	0.00	1.00			
	Group B	Amateur	0.16	0.37	0.00	0.00	639	0.40	***<0.001*** *
		Professional	0.90	1.15	1.00	1.00			
	Group C	Amateur	0.27	0.69	0.00	0.00	428	0.60	***<0.001*** *
		Professional	1.48	1.68	1.00	1.25			

The Mann–Whitney U test was performed. The z-value represents the effect size; * $p < 0.05$.

Apart from that, the analysis of NS according to the AIS classification system among athletes competing in national and international competitions is presented in Table A4.

The total supplement use, Group A, performance supplements, Group B, and Group C supplements were significantly higher in handball players competing at the international level than those participating in national leagues ($p < 0.05$).

4. Discussion

This study evaluated the NS use of elite male and female handball players in Türkiye according to AIS criteria, considering sex and competition level. In the present study, 70.7% of participants indicated that they had used at least one supplement in the past, while the current usage rate was 34.8%. Studies specifically on handball also support this situation. Sekulic et al. reported that 49% of professional handball players ($n = 206$) used at least one supplement regularly [31]. Munoz et al. reported this rate as 59.9% [15]. In another study involving 360 handball players, 65.8% of participants reported supplement usage [32]. These minor differences may be associated with factors such as sample size, sociodemographic characteristics of participants, league level, or sources of information regarding supplement use. Furthermore, habitually using supplements may vary depending on the country and sports culture. The high-contact nature of handball may also increase athletes' tendency to use recovery and performance-enhancing supplements. Therefore, the current findings are generally consistent with literature data and highlight cultural and sport-specific factors that may increase the prevalence of supplement use.

The times of NS use vary among athletes, but they are commonly used during training/competition. Thus, female elite football players (52.4%) [33] and male federated basketball players (51.5%) [34], reported using NS during both training and competition days as first option. In another study, 92% of heavyweight rowers consumed NS before, during, and after exercise, while 8% used them only after exercise [27]. Comprehensive studies on NS usage days and timing in handball players are limited. In the present study, 28.3% of handball players used NS on both training and match/competition days, 18.5% used them throughout the day, and 13% used them only on training days. Regarding timing, 23.9% of athletes used NS before and after sports, 15.2% used them without any specific reason, and 13% used them only before sports. Differences in findings across studies may be explained by training frequency, type, and the high physiological demands of each sport [35].

Athletes' motivations for using NS vary. Sousa et al. found that performance enhancement was the main reason among professional Portuguese athletes [36]. Similarly, Vento and Wardenaar reported performance as the primary motivation in university athletes [37]. Jiménez-Alfageme et al. reported 82.33% used NS to improve performance, 31.47% for health, and 21.98% for both. Less frequent reasons included dietary deficiencies, managing health issues, or mandatory use [13]. Roy et al. reported healthy living (83%), energy boost (71%), recovery support (69%), correcting micronutrient deficiencies (60%), and providing adequate energy/macronutrient support (58%) [38]. In our study, 62% used NS for improving performance, 47.8% for health care, 21.7% for physical appearance, and to overcome health problems (9.8%), sponsorship (3.3%), or legal requirements (1.1%). Thus, performance is the primary driver, with health and appearance as secondary motivations.

The location where NS are purchased plays a critical role in ensuring their appropriate use as it often provides better guidance and access to higher-quality products [39,40]. Molina-Lopez et al. reported Internet (34.9%) and specialty stores (23.8%) as primary sources female elite football players [33]. Similar findings in basketball players show Internet (40.5%) and specialty stores (32.9%) as primary sources too [34]. Baltazar-Martins et al. reported that supplement stores (45%) were the most common source among elite Spanish athletes [41]. In this study, Turkish handball players most frequently buy supplements online, followed by pharmacies, sports nutrition stores, and clubs, reflecting a preference for accessibility and variety. Online purchasing may pose content-related risks,

especially if the country of origin has less strict regulations. In addition, male and professional competing handball players obtain supplements via clubs significantly more than women ($p < 0.05$). This suggests that sport level and sex affect purchasing channels, and that higher-level male athletes benefit from club support, guidance, or sponsorship.

NS purchasing and usage may carry health risks, including low awareness [42,43], undeclared pharmacological agents [44], suboptimal usage protocols [43], and insufficient regulations [45]. Trusted sources and guidance are critical in reducing risks [46]. Proper guidance facilitates access to higher-quality products and reduces health risks.

The literature shows athletes rarely consult professionals for NS use [15,41]. Domínguez et al. reported that 50% of athletes purchased NS on their own, with fewer consulting doctors (25%), dietitians/nutritionists (12.5%), or coaches (12.5%) [27]. Another study reported that dietitians/nutritionists (58.9%), doctors (44.6%), and fitness coaches (36.4%) were key motivational sources [47]. This highlights the importance of guidance for safe and effective supplement use. In the current study, sex, competition level, and type are important factors shaping athletes' NS use motivations. Higher-level and male athletes were more influenced by coaching in supplement use, underscoring the role of professional guidance.

Elite athletes who use supplements make up an important market share and are a key target for supplement companies. Previous studies have estimated NS prevalence among athletes between 40% and 100%, depending on league level and sport disciplines [48,49]. In studies on elite athletes, sports foods such as energy bars (85%) and isotonic drinks (80%) were reported as the most consumed. From medical supplements, iron (85%) and vitamin supplements (80%) were highly consumed [35]. Another study on gym-goers reported the most commonly used NS as magnesium (29.5%), whey protein (27%), vitamin C (20%), and fish oil capsules (17.6%) [50]. Baltazar-Martins et al. observed that the most consumed supplements were proteins, amino acids/BCAA, multivitamins, glutamine, and creatine in elite Spanish athletes [41]. In handball, sports drinks were reported as the most frequently used supplements, followed by energy bars and caffeine products, independent of sex and competition level [15]. Sports drinks and energy bars are also popular in intermittent sports like squash and tennis [22,51]. In the current study, magnesium (37%) was the most consumed supplement among handball players, followed by vitamin C (20.7%), whey protein (19.6%), sports bars (19.6%), vitamin D (19.6%), sports drinks (18.5%), omega-3 (14.1%), caffeine (14.1%), creatine monohydrate (12%), and meat protein (12%).

NS usage levels have been shown to vary by sex, competition level, and supplement type, a pattern consistently supported by the literature. Some studies report higher NS use in higher competitive levels, while women athletes use fewer NS than men at the same competition level [24,32]. Energy bars and isotonic drinks were the most consumed in squash, with over 70% of international and half of the national-level players using them. Whey protein was consumed by less than 43% of international and 30% of national players [22]. Spanish female triathletes consumed more iron supplements but less caffeine than males. International triathletes consumed more sports gels, whereas national-level athletes preferred whey protein and glutamine [13]. In the current study, only magnesium and pre-workout formula use differed significantly between sexes ($p < 0.05$). Magnesium, vitamin C, whey protein, sports bars, sports drinks, and creatine monohydrate differed significantly between amateur and professional athletes ($p < 0.05$). These results suggest that sex- and competition-level differences in NS use may reflect requirements, awareness, knowledge, and guidance variations.

Athletes generally use NS with low levels of evidence due to insufficient knowledge [41,44]. Globally inadequate regulations on supplements, contamination risks during production, and conflicting scientific evidence regarding their use can lead to inadequate and/or excessive use of NS. This situation may even unintentionally increase the doping

risk [45]. A study examining athletes who had used at least one supplement found that four out of five athletes did not know the necessary platforms to verify the safety/quality of supplements. Most athletes rely solely on the brand name for quality and safety. Despite abundant evidence confirming contamination in commercially sold products, athletes still purchase supplements, assuming their safety [41]. These results indicate that athletes are mainly unaware of the contamination risks of supplements. In the present study, 53.3% of participants stated they were familiar with legal regulations regarding NS use, whereas 31.5% had no idea, and 15.2% were unfamiliar with these regulations. Consistent with our findings, the literature shows that elite athletes lack education regarding NS use [52]. Athletes need to understand the possible advantages and negative impacts of NS intended to enhance their health and performance. Educational interventions should assess each supplement within a legal context, taking into account the health condition of the intended audience. This is crucial for minimizing accidental doping incidents and avoiding the intake of substances that may have both immediate and long-term adverse effects.

The consumption pattern observed in our sample indicates that Turkish handball players predominantly used supplements classified in Group A of the AIS framework. This finding is consistent with studies in Spanish handball players, where the majority of supplements consumed also belonged to Group A, particularly sports drinks and whey protein [32]. Similarly, research in other disciplines, such as road cycling, reinforces that Group A supplements are the most widely used and recommended, although some consumption of products with low scientific evidence persists [32]. In line with this, the present study also revealed a notable proportion of Group B and Group C supplementation, highlighting the need for improvement in aligning supplement use with evidence-based recommendations [15].

When analyzed by sex, significant differences were found in the consumption of Group C supplements, with male athletes reporting a higher prevalence of magnesium and pre-workout formula use. This finding does not align with Muñoz et al. (2020), who reported that men's handball players consumed more Group A and B supplements, while women tended to rely more on medical supplements (subgroup A) [15]. Similarly, Romero-García et al. (2024) observed higher male consumption of creatine and caffeine—both classified as Group A—in handball players too [32]. The fact that in our sample men reported greater use of low-evidence products (Group C) reinforces what has been observed in other sports, such as cycling, where male athletes tend to report higher total supplement use and a greater likelihood of using products lacking strong scientific support [21].

Competition level emerged as a determinant factor in supplementation patterns. Professional players reported significantly higher consumption of Group A supplements, as well as Group B and Group C. This finding is consistent with previous research. Romero-García et al. (2024) highlighted higher supplement use among players competing in national and elite leagues compared to provincial levels, although particularly creatine and whey protein [32]. Likewise, Muñoz et al. (2020) identified greater use of medical supplements (subgroup A) and Group B among professionals compared to amateurs [15]. In endurance sports such as cycling, elite athletes also exhibit greater use of evidence-based Group A supplements, although a tendency to continue consuming low-evidence products remains, particularly among men [21]. Taken together, these findings suggest that higher competition levels are associated with increased access to and use of scientifically supported supplements, but also with an elevated risk of consuming less effective products.

The results of this study suggest that although handball players predominantly use Group A supplements—those supported by strong scientific evidence—a considerable consumption of Group B and C products persists, particularly among male and professional athletes. In relation to this, although the use of sports supplements is widespread among athletes, their application is often inappropriate or ineffective [39,49]. This

underscores, on one hand, the necessity for professional nutritional education and guidance to promote the rational use of supplements: (i) correction of a nutrient deficiency that compromises health or performance; (ii) eliciting a specific effect relevant to competition or training; or (iii) providing assurance of adequate nutrient intake [39]; and on the other hand, to minimize the associated risks related to their use [46]. Accordingly, sports institutions, health and performance professionals, coaches, and athletes themselves should adopt a pragmatic and transparent approach that carefully weighs the benefits and risks of supplementation, taking into account factors such as safety, efficacy, and regulatory compliance in sport [16]. In this context, conducting cost–benefit analyses are essential to ensure responsible use, alongside individualized nutritional assessments tailored to the athlete's specific context and needs [46]. It is also important to emphasize that the use of dietary supplements should not compensate for poor food choices and an inadequate diet, except as a short-term strategy when dietary changes are not possible [53]. Moreover, excessive or uncontrolled intake of these products may pose health risks, reinforcing the need to implement educational programs from an early stage to promote informed decision-making among athletes, coaches, and family members [49]. Future efforts should focus on improving access to expert advice, monitoring supplement trends, and fostering the appropriate and responsible use of supplementation by athletes and those who recommend them.

Limitations

This study has several limitations. Firstly, the number of athletes participating in the study ($n = 92$) was limited, making it difficult for the results to represent all handball players. Although handball players from different leagues in Turkey were included, a comprehensive sample covering all leagues and clubs could not be reached. Therefore, the generalizability of the results is limited. Secondly, since the data were collected through a questionnaire, it is not easy to ensure that participants' responses were accurate. Athletes may have concealed the truth or responded according to social expectations regarding NS use. Third, another limitation is the lack of data collected on the athletes' dietary intake. While we recorded the NS used during the season, the absence of detailed dietary information prevents us from establishing the nutritional foundation of their diet and, consequently, the contextual relevance or actual necessity of the consumed NS. Lastly, as no blood or other biological samples were collected from the athletes, self-reported NS use could not be verified through laboratory tests. Therefore, there may be discrepancies between actual use and the information provided.

5. Conclusions

The consumption of NS is prevalent among Turkish handball athletes and exhibits significant differences depending on gender, level of competition, and participation in international events. Most athletes indicated that they have tried at least one NS at some point, while roughly one-third are currently actively using supplements. The most commonly consumed NS include magnesium, vitamins C and D, whey protein, sports bars, and sports drinks. Male athletes, particularly those competing at professional or international levels, tend to use a wider variety and greater amounts of NS and studies indicate that males use more Group C supplements than females. These results underline the importance of applying the AIS classification system to supplement practices. It requires prioritizing scientifically proven Group A supplements while exercising caution regarding those classified as Group B and C. To improve performance, coach-driven motivation, peer pressure, and personal motivation are the primary drivers of NS use. Many NS are purchased from supplement stores or websites, emphasizing the importance of reliable information and regulation.

The management of NS usage in handball should be guided by scientific research and international standards. The approach to managing NS usage in handball should align with global standards and scientific research. To enhance performance and safeguard athlete well-being, initiatives that inform athletes, engage health and nutrition experts, deliver sound coaching advice, and increase awareness of banned substances are essential. Training that prioritizes the selection of appropriate NS, guarantees their safe usage, and obtains them from trustworthy suppliers can mitigate health risks and boost performance results.

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Abbreviations

The following abbreviations are used in this manuscript:

AIS	The Australian Institute of Sport
NS	Nutritional Supplements
OR	Odds Ratio
SD	Standard Deviation

Appendix A

Table A1. Evaluation of parameters related to supplement use by sex.

Factors Affecting Supplement Use			Sex				χ^2	*p* Value	Odds Ratio
			Female		Male				
			n	%	*n*	%			
Purpose of Supplement Use	To Improve Performance	No	22	59.5	13	23.6	12.0	***<0.001*** *	4.74 [1.92–11.7]
		Yes	15	40.5	42	76.4			
	To Maintain Health	No	21	56.8	27	49.1	0.52	0.47	1.36 [0.59–3.15]
		Yes	16	43.2	28	50.9			
	To Enhance Physical Appearance	No	32	86.5	40	72.7	2.46	0.12	2.4 [0.79–7.31]
		Yes	5	13.5	15	27.3			
Place of Supple-	Internet	No	24	64.9	25	45.5	3.35	0.067	2.22 [0.94–5.23]
		Yes	13	35.1	30	54.5			

	Supplement Store	No	32	86.5	42	76.4	1.44	0.23	1.98 [0.64–6.13]
		Yes	5	13.5	13	23.6			
	Club	No	37	100	41	74.5	11.1	***<0.001*** FE,*	26.2 [a] [1.51–455]
		Yes	0	0.0	14	25.5			
Source of Motivation	Coach/ Physical Trainer	No	27	73.0	28	50.9	4.48	**0.034** *	2.6 [1.06–6.39]
		Yes	10	27.0	27	49.1			
	Myself	No	24	64.9	36	65.5	0.003	0.95	0.97 [0.41–2.34]
		Yes	13	35.1	19	34.5			
	Friend	No	33	89.2	37	67.3	5.84	***0.02*** *	4.01 [1.23–13.1]
		Yes	4	10.8	18	32.7			

FE = Fisher's Exact Test; [a] Haldane Anscombe correction applied. Pearson's chi-square test was applied for cases not marked with FE. * $p < 0.05$.

Table A2. Evaluation of parameters related to supplement use by competition level.

Factors Affecting Supplement Use			Competition Level				χ^2	*p* Value	Odds Ratio
			Amateur		Professional				
			n	%	*n*	%			
Purpose of Supplement Use	To Improve Performance	No	22	50	13	27.1	5.11	***0.024*** *	2.69 [1.13–6.42]
		Yes	22	50	35	72.9			
	To Maintain Health	No	25	56.8	23	47.9	0.73	0.39	1.43 [0.63–3.26]
		Yes	19	43.2	25	52.1			
	To Enhance Physical Appearance	No	37	84.1	35	72.9	1.68	0.19	1.96 [0.70–5.49]
		Yes	7	15.9	13	27.1			
Place of Supplement Purchase	Internet	No	31	70.5	18	37.5	10.0	***0.002*** *	3.97 [1.66–9.55]
		Yes	13	29.5	30	62.5			
	Supplement Store	No	37	84.1	37	77.1	0.72	0.40	1.57 [0.55–4.50]
		Yes	7	15.9	11	22.9			
	Club	No	43	97.7	35	72.9	11.0	***<0.001*** FE,*	16.0 [1.99–128]
		Yes	1	2.3	13	27.1			
Source of Motivation	Coach/ Physical Trainer	No	36	81.8	19	39.6	17.0	***<0.001*** *	6.87 [2.63–17.9]
		Yes	8	18.2	29	60.4			
	Myself	No	28	63.6	32	66.7	0.09	0.76	0.88 [0.37–2.07]
		Yes	16	36.4	16	33.3			
	Friend	No	36	81.8	34	70.8	1.52	0.22	1.85 [0.69–4.97]
		Yes	8	18.2	14	29.2			

FE = Fisher's Exact Test. Pearson's chi-square test was applied for cases not marked with FE. * $p < 0.05$.

Table A3. Evaluation of parameters related to supplement use by competition type.

Factors Affecting Supplement Use			Competition Type				χ^2	*p* Value	Odds Ratio
			National		International				
			n	%	*n*	%			
Purpose of Supplement Use	To Improve Performance	No	28	41.2	17	70.8	1.09	0.30	1.70 [0.62–4.64]
		Yes	40	58.8	7	29.2			
	To Maintain Health	No	38	55.9	10	41.7	1.44	0.23	1.77 [0.69–4.55]
		Yes	30	44.1	14	58.3			
	To Enhance Physical Appearance	No	55	80.9	17	70.8	1.05	0.31	1.74 [0.60–5.07]
		Yes	13	19.1	7	29.2			
Place of Supplement	Internet	No	40	58.8	9	37.5	3.24	0.07	2.38 [0.91–6.20]
		Yes	28	41.2	15	62.5			

	Supplement Store	No	57	83.8	17	70.8	1.90	0.17	2.13 [0.72–6.36]
		Yes	11	16.2	7	29.2			
	Club	No	62	91.2	16	66.7	8.26	***0.004*** *	5.17 [1.57–17.0]
		Yes	6	8.8	8	33.3			
Source of Motivation	Coach/ Physical Trainer	No	46	67.6	9	37.5	6.71	***0.01*** *	3.48 [1.32–9.19]
		Yes	22	32.4	15	62.5			
	Myself	No	45	66.2	15	62.5	0.11	0.75	1.17 [0.45–3.09]
		Yes	23	33.8	9	37.5			
	Friend	No	53	77.9	17	70.8	0.49	0.48	1.45 [0.51–4.16]
		Yes	15	22.1	7	29.2			

FE = Fisher's Exact Test. Pearson's chi-square test was applied for cases not marked with FE. * $p < 0.05$.

Table A4. Number of NS used according to AIS evidence level, by competition type.

AIS Evidence Level Classification			Mean	SD	Median	IQR	U Value	z	*p*
Total Supp. Consumption		National (n = 68)	2.04	2.68	1.00	3.00	571	0.30	***0.025*** *
		International (n = 24)	4.38	4.97	3.00	6.00			
Group A	*Group A Total*	National (n = 68)	1.31	1.91	0.50	2.00	599	0.27	***0.042*** *
		International (n = 24)	2.46	2.73	1.00	3.25			
	Sports Foods	National (n = 68)	0.81	1.41	0.00	1.00	691	0.15	0.204
		International (n = 24)	1.50	2.13	0.00	2.25			
	Medical Supplements	National (n = 68)	0.77	1.35	0.00	1.00	685	0.16	0.183
		International (n = 24)	1.42	1.93	0.00	2.25			
	Performance Supplements	National (n = 68)	0.28	0.51	0.00	0.25	682	0.17	0.133
		International (n = 24)	0.46	0.59	0.00	1.00			
Group B		National (n = 68)	0.43	0.82	0.00	0.00	603	0.26	***0.025*** *
		International (n = 24)	0.88	1.19	1.00	1.00			
Group C		National (n = 68)	0.63	0.90	0.00	1.00	577	0.29	***0.020*** *
		International (n = 24)	1.67	2.22	1.00	3.00			

The Mann–Whitney U test was performed. The z-value represents the effect size; * $p < 0.05$.

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