DOI 10.26773/smj.241008

SportMont

ORIGINAL SCIENTIFIC PAPER

Dietary Supplementation in Competitive Swimming: Analysis of Prevalence and Gender-Differences

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Abstract

Dietary supplementation (DS) is an important factor in contemporary sports, but studies rarely have examined DS practices in high-level swimming. The aim of this study was to investigate the practice of DS in professional swimming, emphasizing the differences between male and female swimmers. The participants were 301 swimmers from Slovenia (148 females; 16.7±2.1 years of age; 9.2±3.1 years of experience in swimming sports), comprising the population of swimmers from Slovenia who competed at the highest level of national competition. Variables were collected via a previously validated questionnaire tool and included DS factors (i.e., knowledge of DS, boundaries, sources of information) and specific usages of the different supplements. The chi-square test and Mann–Whitney test (MW) were used to evaluate differences between genders. Only 30% of the studied swimmers reported not using the DS. Isotonics and vitamins/minerals are mostly used (19% and 18% of regular users, respectively). Males use DS more often than females do (MW=2.90, p=0.03), with a higher consumption of carbohydrates and amino acids in males (MW=2.53 and 2.14, respectively, p<0.05). More than one-third of the swimmers were self-educated at DS, and more than 70% of them declared self-procurement at DS. The results revealed the expected figures of DS in swimming but also highlighted the necessity for objective evaluation of the knowledge of DS in swimming athletes. Further studies are needed to clarify the templates of DS in different age groups.

Keywords: *nutrition, nutritional supplements, athletes, sex-differences*

Introduction

Proper nutrition can enhance training adaptations, improve recovery, and optimize competitive performance; therefore, it is generally accepted that nutrition plays a critical role in sports performance, including swimming (Debnath, Chatterjee, Bandyopadhyay, Datta, & Dey, 2019; Shaw, Boyd, Burke, & Koivisto, 2014). More specifically, most competitive sports, particularly swimming, demand high energy expenditures; therefore, adequate intake of carbohydrates, the primary fuel source for muscles, ensures optimal energy levels during training and competition. Next, intense training causes muscle breakdown, while sufficient protein intake provides the building blocks (amino acids) for muscle repair and growth, leading to increased strength and power. Proper nutrition post-exercise speeds up recovery by replenishing glycogen stores (stored carbohydrates) and facilitating muscle repair, which allows for faster adaptation to training stress and improved performance over time. Maintaining proper fluid balance is crucial for optimal performance and preventing dehydration. Intense training can temporarily suppress the immune system, while adequate intake of vitamins, minerals, and antioxidants supports immune function, reducing the risk of illness and missed training days (Shaw et al., 2014). Nutrition plays a key role in achieving and maintaining optimal body composition, and in

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swimming, this role is particularly important since it includes a balance of muscle mass and a low body fat percentage to enhance performance and reduce drag in the water. Finally, proper nutrition supports cognitive function, improving focus, reaction time, and decision-making during training and competition, which are all important determinants of swimming performance (Royall, 2016).

Dietary supplementation (nutritional supplementation) can play a role in addressing potential gaps in an athlete's nutrition that may arise from inadequate dietary intake or increased nutrient demands due to intense training (AbuMoh'd, Obeidat, & Alsababha, 2021; Rodek, Sekulic, & Kondric, 2012). Although dietary supplementation (DS) should not be seen as a replacement for a well-balanced diet but rather as a complementary tool to optimize performance and support overall health, contemporary swimming training frequently places great overall stress on athletes' bodies; therefore, DS is frequently found to be highly important and necessary (Alfieri, D'Angelo, & Mazzeo, 2023). For example, even with a carefully planned diet, swimmers may fall short on certain vitamins and minerals owing to factors such as limited food variety, poor absorption, or increased needs from training. Therefore, DS can help bridge these gaps and ensure adequate micronutrient levels for optimal health and performance. Swimmers engaging in intense training require a significant amount of energy, and if dietary intake is inadequate, DS with carbohydrates and protein-based ingredients can help meet these increased needs and support optimal recovery (Dhiman & Kapri, 2023). Certain supplements (i.e., creatine, beta-alanine, and caffeine) have been shown to enhance specific aspects of swimming performance, such as power, endurance, and mental focus, and these supplements can be considered if dietary intake alone is not sufficient to achieve performance goals. Finally, swimmers with specific dietary restrictions, such as vegans or those with food allergies, may require DS to ensure adequate intake of nutrients that are challenging to obtain through their diet (Burke, 2007; Correa, 2014).

Not surprisingly, studies have investigated the problem of nutrition and DS in swimming, and reference studies can be clustered into several groups. The first group of investigations examined the nutritional needs of swimmers. In brief, swimmers require high carbohydrate intake (6–12 g/kg/day) to support training demands, whereas protein intake of 2 g/kg/day is recommended, with an emphasis on postexercise consumption (Dominguez et al., 2017; Shaw et al., 2014). Another group of studies examined the effectiveness and appropriateness of DS. In brief, various supplements, including caffeine, creatine, sodium bicarbonate, beta-alanine, and whey protein, have shown potential benefits, while creatine supplementation may improve repeated interval swim performance and power development (Leenders, Lamb, & Nelson, 1999; Mero et al., 2013; Norberto et al., 2020; Peyrebrune, Nevill, Donaldson, & Cosford, 1998). Adequate intake of micronutrients, particularly iron, zinc, and vitamins A, D, E, B6, and B12, is essential for maintaining health and performance, and DS is found to be a convenient way to supplement the lack of micronutrients due to the limited bioavailability of these compounds in a regular diet (Pyne, Verhagen, & Mountjoy, 2014). Furthermore, some studies have investigated problems related to the nutrition of swimmers and have reported inadequate calcium intake and potential risks of eating disorders among swimmers, which clearly support the need for DS to prevent risks related to a lack of this mineral (Paschoal & Amancio, 2004).

While there is no doubt that nutrition is a cornerstone of success in swimming, DS is considered an important factor in reaching optimal nutrient levels, especially in high-level competitive swimming. However, studies in which DS practices were directly examined in high-level swimmers from different teams are lacking. Therefore, this study aimed to investigate the practice of DS in professional swimming, emphasizing the differences between male and female swimmers. It was hypothesized that DS would be more prevalent in male swimmers than in their female peers.

Methods

Participants

The sample in this study included 301 swimmers from Slovenia (148 females; 16.7±2.1 years of age; 9.2±3.1 years of experience in swimming sports). All participants were active swimmers and competed at the highest level of national competition (National Championship). An invitation to participate in the study was sent by the national swimming federation, and none of the athletes refused to participate; therefore, all swimmers who participated in the championship were included, and the tested sample represented the entire population of competitive swimmers from the country. For underage participants, one parent/guardian signed informed consent for study participation, whereas adult swimmers signed consent for their own participation. The study was originally initiated and approved by the national swimming federation, complied with all ethical guidelines and received approval from the Institutional Ethics Review Board of the Faculty of Sport, University of Ljubljana, Slovenia (EBO 10/09/2014-1).

Variables

Variables were collected via a previously validated questionnaire tool (Kondric, Sekulic, Uljevic, Gabrilo, & Zvan, 2013; Rodek et al., 2012). The questionnaire consisted of queries about the following: the swimmers' self-knowledge about DS (self-assessed on a five-point scale ranging from "I have no knowledge at all" to "Excellent"); the primary source of trusted information about DS (possible answers included "I have no knowledge", "Coach, physician", "Formal education", and "Self-education"); and the way of procurement/purchasing of DS (with possible answers: "Medical team", "Coach", "Personally"). Specific DS usage was reported in response to one main question (e.g., "Do you use DS?", and possible responses were "Yes, regularly", "From time to time", and "No, I don't use it") and separate responses regarding the consumption of vitamins and minerals, carbohydrates, proteins, isotonics, recovery supplements, energy bars, and other supplements. For all supplements, four-point scales were offered ("No", "Sporadically", "Often", "Regularly"). Those who did not and/or only sporadically consumed supplements were asked why he/she did not use DS (the answer options were "I don't think it will be useful; I have a proper diet"; "I don't have sufficient knowledge to use DS", "DS is expensive", "I don't think DS is healthy").

Statistics

Descriptive statistics for swimmers' age and experience in competitive swimming included calculations of means and standard deviations. For the remaining study variables, counts (frequencies) and proportions were calculated. Differences be-

tween genders for ordinal variables were established via the nonparametric Mann–Whitney test, whereas the chi-square test was applied to identify differences between genders for nominal variables.

A statistical significance level of 95% ($p<0.05$) was applied. Statistical analyses were performed via Statistica (Tibco Inc.) Version 13.5.

Results

Descriptive statistics and differences between genders for DS factors are presented in Table 1. In general, DS usage is relatively common, with only 30% of the studied swimmers declaring no usage of the DS. Males use DS more often than females do (MW=2.90, p=0.03). A relatively small percentage of the participants reported a lack of knowledge of DS, with <4% reporting a total lack of knowledge and <10% reporting poor knowledge of DS. More than one-third of the swimmers were self-educated at DS, and more than 70% of them declared self-procurement at DS.

Table 1. Descriptive statistics (F – frequencies, % - percentages) and differences between genders (MW – Mann–Whitney test, Chi²—Chi-square test) in dietary-supplementation factors for Slovenian swimmers

	Males		Females		MW/Chi2 (p)	
	F	%	F	%		
Knowledge on dietary supplementation MW					0.56	(0.57)
Very poor	2	1.35	6	3.92		
Poor	12	8.11	16	10.46		
Average	80	54.05	64	41.83		
Good	48	32.43	59	38.56		
Excellent	6	4.05	8	5.23		
Missing	0	0.00	0	0.00		
Main source of information on dietary supplementation Chi					0.35	(0.95)
I have no knowledge	21	14.19	24	15.70		
Coach/physician	33	22.30	33	21.57		
Formal education	38	25.68	42	27.45		
Self-education	56	37.84	54	35.29		
Missing	0	0.00	0	0.00		
Dietary supplement usage MW					2.90	(0.03)
Yes, regularly	34	22.97	13	8.50		
Yes, from time to time	68	45.95	77	50.33		
No, I don't use it	46	31.08	63	41.18		
Missing	0	0.00	0	0.00		
Procurement of dietary supplements Chi					0.32	(0.85)
Medical team	4	2.70	3	1.96		
Coach	11	7.43	8	5.23		
Personally	115	77.70	107	69.93		
Missing	18	12.16	35	22.88		
Limitation/boundary on usage of dietary supplements Chi					7.79	(0.05)
I don't think it will be useful, my nutrition is good	38	25.68	47	30.72		
Lack of knowledge.	25	16.89	37	24.18		
Price	26	17.57	15	9.80		
Health hazard	14	9.46	8	5.23		
Missing/have no boundaries	45	30.41	46	30.07		

Legend: MW – differences calculated via the Mann–Whitney test; Chi – differences calculated via the chi–square test

The overall consumption of the DS is presented in Figure 1.

The specific DS used and the differences between genders are presented in Table 2. Isotonic/electrolyte drinks are the most commonly used DS, with >25% of swimmers using them regularly and an additional 10% using them from time to time. The second most commonly used DS is vitamins/minerals (24% of males and 13% of females who are regular users). Iron supplementation is more common in women (there is no significant difference between genders), with more than 16% of females and <5% of males using it regularly. Significant differences between the genders were detected for carbohydrate supplementation (MW=2.53, p=0.01) and amino acid supplementation (MW=2.14, p=0.03). In both cases, males used it more often than females did.

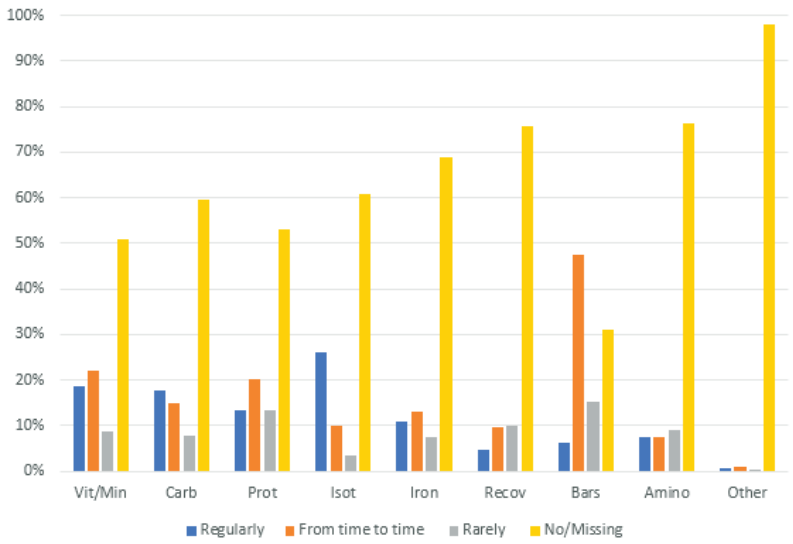

FIGURE 1. Prevalence of dietary supplementation in Slovenian swimming

Table 2. Descriptive statistics (F – frequencies, % - percentages) and differences between genders (MW – Mann–Whitney test) in dietary supplement usage for Slovenian swimmers

	Males		Females		MW (p)	
	F	%	F	%		
Vitamins/Minerals					0.21	(0.83)
Regularly	36	24.32	20	13.07		
From time to time	29	19.59	37	24.18		
Rarely	12	8.11	14	9.15		
No/Missing	71	47.97	82	53.59		
Carbohydrates					2.53	(0.01)
Regularly	33	22.30	20	13.07		
From time to time	29	19.59	16	10.46		
Rarely	10	6.76	13	8.50		
No/Missing	76	51.35	104	67.97		
Proteins					1.51	(0.13)
Regularly	30	20.27	10	6.54		
From time to time	35	23.65	26	16.99		
Rarely	16	10.81	24	15.69		
No/Missing	67	45.27	93	60.78		
Isotonics/Electrolyte drinks					1.90	(0.06)
Regularly	52	35.14	26	16.99		
From time to time	14	9.46	16	10.46		
Rarely	3	2.03	7	4.58		
No/Missing	79	53.38	104	67.97		
Iron based supplements					0.80	(0.41)
Regularly	7	4.73	26	16.99		
From time to time	23	15.54	16	10.46		
Rarely	15	10.14	7	4.58		
No/Missing	103	69.59	104	67.97		
Recovery supplements					1.47	(0.13)
Regularly	14	9.46				
From time to time	15	10.14	14	9.15		

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Table 2. Descriptive statistics (F – frequencies, % - percentages) and differences between genders (MW – Mann–Whitney test) in dietary supplement usage for Slovenian swimmers

	Males		Females		MW (p)	
	F	%	F	%		
Rarely	14	9.46	16	10.46		
No/Missing	105	70.95	123	80.39		
Energy bars					0.19	(0.84)
Regularly	11	7.43	8	5.23		
From time to time	70	47.30	73	47.71		
Rarely	23	15.54	23	15.03		
No/Missing	44	29.73	49	32.03		
Amino-acid supplementation					2.14	(0.03)
Regularly	17	11.49	5	3.27		
From time to time	14	9.46	8	5.23		
Rarely	13	8.78	14	9.15		
No/Missing	104	70.27	126	82.35		
Other					0.04	(0.96)
Regularly	1	0.68	1	0.65		
From time to time	1	0.68	2	1.31		
Rarely	1	0.68				
No/Missing	145	97.97	150	98.04		

Discussion

With respect to the study aims, the results revealed two important findings. First, male swimmers consume DS more often than females do. Second, specific differences between genders are evident in the consumption of protein-based supplements (e.g., amino acids) and carbohydrates. Therefore, the initial study hypothesis can be accepted. Before these findings are discussed, the most important results concerning the prevalence of DS consumption in swimmers are reviewed.

The prevalence of DS in the studied swimmers was relatively high, with only 30% of the studied participants reporting no consumption. However, these results are expected, given that previous studies reported even higher consumption of DS in athletes. Studies suggest that 35% to 100% of athletes report using dietary supplements, with reasons ranging from performance enhancement to recovery support and general health maintenance (Baltazar-Martins et al., 2019; Garthe & Maughan, 2018). Research specifically on swimmers aligns with these general trends. One study on competitive swimmers reported that 79.5% used supplements, with higher usage among national-level athletes (Jimenez-Alfageme et al., 2022). Another investigation into a high-performance swimming club revealed that the majority used supplements, often consuming more than those in development groups did (Newbury, Sparks, Cole, Kelly, & Gough, 2023). However, the results of relatively high consumption of DS are interesting if we consider that the study included not only adult (e.g., senior-level) competitors but also youth categories (please see Methods for details). Despite the background, which is gender- and age specific, the relatively high prevalence of DS in swimmers is relatively understandable.

As discussed in the introduction, DS in swimming are aimed primarily at enhancing performance, supporting recovery, and addressing specific nutritional needs that may arise from the intense training demands of the sport (Alfieri et al., 2023; Burke, 2007; Pyne et al., 2014). Indeed, swimming training and competitions are highly exhaustive. Although the usual volume of training in swimming varies depending on the swimmer's level, age, and goal, competitive swimmers typically train between 5,000 and 10,000 meters per day. This translates to approximately 2–4 hours in the pool per session, often spread across two daily workouts. In addition, high-level swimmers regularly perform additional training in gyms of 4–5 hours per week, which additionally increases the overall volume of training. Therefore, the relatively high prevalence of DS in the studied swimmers could be considered a logical consequence of the high energetic demands of training.

The fact that the majority of swimmers purchase DS individually points to the fact that most of them are actually not properly monitored with regard to the consumption of DS. In other words, even if swimmers are advised to consume specific supplements, individual purchases increase the risk of improper consumption and dosing. This is a particularly dangerous practice because of the two most important issues. First, studies repeatedly highlighted the problem of improper consumption of supplements, which can lead to various health problems, including (i) overdose and toxicity (consuming excessive amounts of certain supplements can lead to toxicity), (ii) nutrient imbalances (taking high doses of one nutrient can interfere with the absorption or utilization of others), (iii) drug interactions (some supplements can interact with prescription or over-the-counter medications, altering their effectiveness or increasing the risk of side effects), and (iv) allergic reactions (certain ingredients in supplements can trigger allergic reactions in susceptible individuals) (Palmer et al., 2003)

Apart from those health-related side effects, many sup-

plements are marketed with exaggerated or misleading claims, creating unrealistic expectations about their benefits, which can lead to disappointment and wasted money. Second, and important is the contamination of supplements with doping agents. In brief, supplements can be contaminated with banned substances (i.e., doping substances). Such contamination poses a serious risk in sports, impacting both athletes' careers and their health. Unfortunately, this issue is prevalent globally and well documented even in the scientific literature (Van Thuyne, Van Eenoo, & Delbeke, 2006). For that reason, monitoring DS in athletes should be highly prioritized.

The consumption of DS is greater in males than in females, and this finding is generally in agreement with reports from other sports (Aguilar-Navarro et al., 2021). Although there are considerable differences in the type of DS used between genders, the generally higher prevalence of DS in males will be briefly discussed, with several potential reasons for such differences. First, regardless of the type of sport athletes are participating in, societal pressures and cultural norms often emphasize muscle mass and strength for men. This can lead to greater pressure on male athletes to achieve a certain physique, leading them to seek out supplements that promote muscle growth or enhanced performance. Second, men generally have greater caloric needs and may require more nutrients, which are difficult to obtain throughout a regular diet. This can lead to a greater reliance on DS to meet these nutritional demands.

Additionally, DS marketing often targets men, focusing on messages of strength, power, and masculinity (Noonan & Patrick Noonan, 2006). This can lead to the perception that DS are primarily for men and may influence their usage patterns. Finally, men may have greater exposure to information about DS through sports media, fitness communities, and peer groups, which can increase their awareness and willingness to try these products. Together, these findings are definitively associated not only with a higher prevalence of DS but also with the types of DS in male and female swimmers.

The most evident difference between genders in DS is the consumption of carbohydrates and proteins (amino acids), with a greater prevalence in men. This finding actually supports previously specified explanations for the higher prevalence of DS in males. However, the background of a specific DS is also interesting. With regard to carbohydrates, the following explanations are possible. First, men typically have a larger body size and muscle mass than women do, leading to a higher metabolic rate and greater energy expenditure during exercise (McMurray, Soares, Caspersen, & McCurdy, 2014). Together, these factors often necessitate increased carbohydrate intake to fuel training and performance. Compared with their female counterparts, male swimmers often engage in training programs with greater volume and intensity, and this increased training load further increases their energy requirements, making greater carbohydrate intake crucial for optimal performance and recovery. Finally, men have greater muscle mass and consequently have a greater capacity to store glycogen, requiring greater carbohydrate intake to replenish these stores after intense training sessions.

While both male and female swimmers need adequate quantities of proteins and amino acids for muscle repair and recovery, a few factors might contribute to increased protein-based DS among male swimmers. First, men generally have a greater percentage of muscle mass than women do (Malina, 2007). The pursuit of increased muscle mass and strength, which is often emphasized in male-dominated sports culture, may lead male swimmers to consume more protein and utilize supplements to support those goals. Furthermore, traditional dietary patterns may lead men to consume more protein-rich foods, such as meat and dairy, than women do, which creates a certain "culture" of protein-based nutrition in male athletes. Male swimmers are regularly engaged in more strength-focused training alongside their swimming routine. Therefore, their protein requirements might be slightly greater to support muscle growth and repair. Finally, in addition to those physiologically based mechanisms, DS marketing often targets men with messages of strength and muscle gain, potentially influencing their DS choices.

The most important limitation of the study is that the DS was self-reported; therefore, there might be concerns about the accuracy of the answers. However, the author believes that the strict anonymity of the questionnaire, as well as the fact that participants were not asked about issues that may be under the influence of "social desirability," decreased the possibility that swimmers did not respond honestly. Additionally, this study investigated athletes from only one country; therefore, the results are generalizable to similar samples (i.e., swimmers from countries with similar cultural backgrounds and cultures).

This is one of the rare studies performed in southeastern Europe where the DS of high-level swimmers were evaluated. The participants were tested with a specific, reliable, and previously validated questionnaire, which is another important strength of the study. Therefore, although results are not the final word on a topic, this study will hopefully broaden the knowledge in a field and initiate further research.

Conclusion

The prevalence of DS in the studied swimmers was in line with previous reports. However, further studies are needed to clarify the templates of DS in different age groups. Specifically, the sample of participants in this study included swimmers of different age categories; therefore, more detailed age-specific analyses are needed.

The fact that the majority of the studied swimmers purchase DS individually, with no proper supervision of educated and certified specialists, is alarming. Seeking guidance from a specialist is crucial to ensure that DS are safe, effective, and tailored to athletes' individual needs and goals. This can help swimmers optimize performance, promote recovery, maintain overall health, and avoid the risk of consuming illegal (banned) substances.

Males consume more DS than females do. While this was expected, attention should be given to the relatively high consumption of protein-based supplements in male swimmers. Specifically, although protein supplementation can be beneficial for swimmers, there can be misconceptions about the amount of protein needed for optimal performance and recovery, leading to unnecessary supplementation. If dietary protein intake is sufficient, additional supplementation might not be necessary. Therefore, it is of utmost importance to educate athletes that the overconsumption of protein can have negative health effects, and it is essential to strike the right balance to support optimal performance and recovery without compromising overall health.

Acknowledgements
There are no acknowledgments.

Conflicts of interest
The authors declare that there are no conflict of interest.

Received: 05 September 2024 | **Accepted:** 25 September 2024 | **Published:** 01 October 2024

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