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Research article

Sports Nutrition and Doping Factors in Synchronized Swimming: Parallel Analysis among Athletes and Coaches

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Abstract
Although nutrition and doping are important factors in sports, neither is often investigated in synchronized swimming (Synchro). This study aimed to define and compare Synchro athletes and their coaches on their knowledge of sports nutrition (KSN) and knowledge of doping (KD); and to study factors related to KSN and KD in each of these groups. Additionally, the KSN and KD questionnaires were evaluated for their reliability and validity. Altogether, 82 athletes (17.2 ± 1.92 years of age) and 28 coaches (30.8 ± 5.26 years of age) from Croatia and Serbia were included in the study, with a 99% response rate. The test and retest correlations were 0.94 and 0.90 for the KD and KSN, respectively. Subjects responded equally to 91% queries of the KD and 89% queries of the KSN. Although most of the coaches are highly educated, they declared self-education as the primary source of information about doping and sport-nutrition. Coaches scored higher than their athletes on both questionnaires which defined appropriate discriminative validity of the questionnaires. Variables such as age, sports experience and formal education are positively correlated to KSN and KD scores among athletes. The athletes who scored better on the KD are less prone to doping behavior in the future. These data reinforce the need for systematic educational programs on doping and sports nutrition in synchronized swimming. Special attention should be placed on younger athletes.

Key words: Dietary supplements, reliability, validity, knowledge.

Introduction

Synchronized swimming (synchro) is an Olympic sport and a performing art; a combination of ballet, swimming and dance in which athletes (solos, duets or teams) perform a synchronized competitive routine of highly structured moves in and under water. Studies have confirmed that synchro performance depends on strength, flexibility, coordination and both aerobic and anaerobic endurance (Alentejano et al., 2012; Bante et al., 2007; Gabrilo et al., 2011; Naranjo et al., 2006; Peric et al., 2012; Sajber et al. 2013a).

As in any other sport, a synchro swimmer's achievement depends on their genetic background, systematic training and the socio-cultural context where the athlete was raised. However, proper nutrition (including hydration) is one of the key optimization factors in the overall sports training process (Caccialanza et al., 2007; Poole et al., 2010). In modern sports, nutritional supplementation (NS) is considered valuable to support regular nutrition (Jouris et al., 2011; Kondric et al., 2011; McDowall, 2007). The NS describes preparations intended to supplement the diet and provide nutrients such as vitamins, minerals, fiber, fatty acids or amino acids that may be lacking in a person's diet. Not surprisingly, 50% to 93% of athletes use NS, with 53% of young synchro swimmers using NS according to a recent report (Dascombe et al., 2010; Huang et al., 2006; Kondric et al., 2010; Zenic et al., 2010).

When all optimization factors, including NS, fail to provide the results athletes are striving for, the temptation to start doping emerges. In its most common sense, doping is defined as the occurrence of one or more anti-doping code violations, usually observed by the presence of a prohibited substance, its metabolites or markers in a biological specimen from an athlete (WADA). Doping can cause serious health problems, including death and it is considered an unethical and unfair practice that allows one to go beyond his or her natural genetic potential (Rodek et al., 2012).

Although recognized as important factors in an athlete's overall development and health status, nutrition, NS and doping issues are rarely studied in synchro (Lundy, 2011). To the best of our knowledge, only one study has investigated NS and doping in synchro (Zenic et al., 2010). Apart from the prevalence of NS usage (53% of studied athletes used some kind of the NS), the authors found some indirect evidence for deficient knowledge about NS and doping among synchro athletes. Additionally, their results showed that synchro athletes, in general, do not rely on their coaches' opinion about NS and doping. Both findings are highly disconcerting. First, proper knowledge of NS and doping are crucial for appropriate nutritional practices and awareness of doping health-hazards. It is especially important knowing the problem of the possible contamination of the NS with doping agents (Maughan, 2005; Van Thuyne et al., 2006). Second, coaches are most closely involved in and connected to an athlete's sports-development; therefore, the mutual trust in an athlete-coach relationship is essential, not only as a factor that influences achievements in sports but, more importantly, as a factor that can directly influence an athlete's health status (Kondric et al., 2013). Therefore, to increase an athlete's trust in their coaches regarding NS and doping, the first step is to objectively determine the knowledge that both athletes and coaches have on these issues.

The aims of this study were to determine and com-

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pare the knowledge of sports nutrition and doping between synchro athletes and their coaches and to clarify the factors related to knowledge of doping and sports nutrition. In the first phase of this investigation, we designed and validated a questionnaire that sought to provide evidence of knowledge concerning (a) nutrition and nutritional supplementation (knowledge of sports nutrition – KSN) and (b) doping issues in sports (knowledge of doping – KD). We thought that such approach will allow us to determine the background of the previously reported low trust of the synchro athletes in their coaches' competence regarding nutritional and doping issues (Zenic et al., 2010).

Methods

Sample and testing design

The subjects were junior- (15-to-18 years of age) and senior-level (18+ years) synchro athletes from Croatia and Serbia and their coaches who participated in the 2010-2011 competitive season. Altogether, 82 athletes (50 and 32 from Croatia and Serbia respectively; 17 ± 1.92 years of age) and 28 coaches (19 and 9 from Croatia and Serbia respectively; 30 ± 5.26 years of age) were evaluated. The testing design consisted of two parts: the reliability study and the main study. The reliability study was performed to determine the reliability of the KD and KSN questionnaires. In this part of the experiment, 15 subjects (10 athletes and 5 coaches) were evaluated twice within 10 days using a test-retest procedure for both questionnaires. The participants in the study were anonymous, and we did not collect personal data such as date of birth, city of residence, etc. We asked the subjects to use a self-determined, confidential code for identification. The codes were used to compare the test and retest results of those subjects who participated in both evaluations. All of the answer options were in multiple choice closed-ended formats. Before the survey was administered, the complete procedure and study aims were explained to all participants and to at least one parent of minor subjects (less than 18 years of age). Informed consent was obtained. The subjects were tested in groups of at least three. Each subject was informed that the survey was strictly anonymous, that they could refuse to participate and that they could leave some of the questions and/or the entire questionnaire unanswered. The response rate was over 99%. The study complied with all of the ethical guidelines and was approved by the Institutional Ethics Board.

Variables

Apart from age and highest educational level achieved (based on a four-point scale ranging from primary school to university degree), the other variables included sports factors, sports nutrition questions, doping-related questions, KSN, and KD.

The sports factors included gathering information about the subjects' sports experience in years (participation for athletes and coaching for coaches) and the achievements in the sport as an athlete or coach.

Sports nutrition and doping-related factors were studied through questions about the participant's opinion about doping practices in synchro swimming (a four-point scale from "I do not think doping is used" to "Doping is often used"); the main source of information regarding sport-nutrition and doping (possible responses were: "I have no knowledge", "Coach", "Formal education", "Self education"); , the KSN and KD.

KSN and KD were already used for swimming and tennis (Sajber et al. 2013b; Kondric et al. 2013). However some sport-specific questions were adapted as originally suggested. Originally, a panel of professional and scientific experts within the field of sports nutrition and doping (including academics and professionals from the National Anti-Doping Agency) were consulted to construct a clear and understandable questionnaire. The questionnaire was created to contain sport-specific elements and problem-oriented questions and to be a valid form of evaluation. Both questionnaires consisted of 18 questions each. Each question (statement) was in a "true – false – not sure" form; a correct answer scored one point and otherwise scored a zero. Following a preliminary factor analysis (see Statistics for details), the retained answers were summed separately for the KSN and KD questionnaires. All of the questions are presented in the tables.

Statistics analysis

The Pearson's coefficient of the linear test-retest correlation was used as a first measure of reliability for the KSN and KD. Moreover, we calculated the percentage of the matching test-retest answers (i.e. equally responded queries). The dependent samples *t*-test was used to evaluate potential learning effects between the test and retest of the KD and KSN questionnaires.

To determine the construct validity of the KSN and KD questionnaires, exploratory factor analyses were carried out using the principal component analysis extraction method (Guttman-Kaiser criterion) and a varimax rotation. The exploratory factor analysis suggested which items should be deleted and determined the factors for the scale. A factorial load of 0.50 was chosen as the threshold, and items with a factorial load below this value were excluded.

Data are presented throughout descriptive statistics (means and standard deviations or frequencies and percentages). The t-test for independent samples was used to define differences between coaches and athletes on their scores achieved on KD and KSN. To determine associations between studied variables Spearman's correlations were calculated. Values were considered statistically significant when $p < 0.05$. Statistical analyses were performed with StatSoft STATISTICA Version 10 (Tulsa, OK).

Results

Reliability analysis of the KD and KSN questionnaires revealed high test-retest correlation coefficients for both questionnaires (0.94 and 0.90, respectively). Subjects responded identically to 91% (KD) and 89% (KSN) of the queries. Significant differences between the test and retest suggest learning effects on both tests (Table 1).

Both exploratory factor analyses (Tables 2 and 3) extracted seven significant factors, and the models explained 66% and 71% of the variance for the KSN and the

KD responses, respectively. Initially, we had decided to use a factor loading of 0.50 as a threshold. As a result, items 11 and 12 (of the KD) and items 1, 5, 7, 14, 15, and 16 (of the KSN) were excluded from further analysis. It resulted in a total range of 0 to 16 (the maximum of 18 minus 2) for the KD and 0 to 12 for the KSN. Factor structures are not interpretable because factor loadings do not show a consistent pattern related to different nutrients (for the KSN questionnaire) and/or other doping-related questions (for the KD questionnaire).

Table 1. Test – retest reliability analysis of the knowledge on sport nutrition (KSN) and knowledge on doping (KD) questionnaires (dependent samples T-test; r – test-retest correlation; %ERQ – percentage of equally responded queries). Data are means (±SD).

	Test	Retest	r	%ERQ
KD	5.01 (1.86)	5.45 (1.69) *	.94 *	91%
KSN	5.58 (1.88)	6.20 (1.85) *	.90 *	89%

* $p < 0.05$

Two-thirds of coaches and one-third of athletes declared self-education as the primary source of information on doping and NS. One third of coaches and about 20% of athletes believe that doping is present in synchro (Table 4).

Coaches scored significantly higher than athletes on KSN and KD (Table 5).

Table 5. Knowledge on doping (KD) and knowledge on sport nutrition (KSN) among athletes and coaches, t-test analysis of the differences. Data are means (±SD).

	ATHLETES	COACHES
KD	4.59 (2.65)	6.57 (3.28) *
KSN	5.56 (2.89)	8.14 (3.11) *

* denotes significant differences at $p < 0.05$.

The older and, consequently, more experienced and educated athletes scored higher on the KSN and KD. Among athletes, the KSN and KD are highly correlated; and those who achieved a better score on the KD questionnaire are less prone to doping behavior in the future. The more experienced coaches had a better KD, and those with higher formal education are associated with a better KSN score. The coaches who scored higher on the KD are more convinced that there is doping in synchro (and vice-versa) (Table 6).

Table 2. Factor analysis for KD (F – factor structure; Expl.Var. – explained variance; Prp.Totl – total percentage of the explained variance).

	F1	F2	F3	F4	F5	F6	F7
1. Caffeine is considered to be doping if its concentration in urine exceeds a certain level.	.86	-.05	.11	-.09	.08	.06	-.03
2. Erythropoietin (EPO) is a doping substance used almost exclusively in strength-and-power sports (e.g., weightlifting).	-.06	-.08	.13	.03	.03	.04	.82
3. If sample A is positive for doping, an athlete is entitled to ask for another sampling.	.15	.85	-.13	.00	.04	.05	-.02
4. Doping control officers should notify athletes of their testing intentions a few hours prior to any testing.	.10	.28	-.29	.06	.15	.54	.01
5. If an athlete has an out-of-competition doping control, four weeks should elapse before the next doping control.	-.01	-.22	.06	.07	-.22	.81	-.01
6. If a doping control officer does not provide valid proof of identity an athlete can refuse to participate in the testing.	.24	.26	.10	.02	.24	.62	.09
7. Anabolic steroids used among female athletes have neither positive nor negative effects.	.82	-.05	-.03	.28	-.09	.16	-.13
8. Diuretics are prohibited substances in sport.	-.17	-.10	.03	.82	-.12	.25	-.11
9. In the case of asthma, I can use diuretics.	-.01	-.26	.04	-.13	.67	-.17	.26
10. A “masking agent” is someone who helps an athlete hide their use of doping and is therefore equally responsible for doping offenses.	-.06	.22	.17	-.06	.69	.18	-.29
11. EPO is detected in blood samples.	.45	.17	-.12	-.06	.27	-.03	.36
12. A person caught with material evidence of EPO (for example, ampules containing EPO) can be charged as a doping-offender.	.42	.34	.03	-.01	.28	.34	.28
13. The use of amphetamines has been related to several cases of death in sport due to cardiovascular failure.	.15	-.08	.80	.11	.04	-.01	-.08
14. The use of amphetamines by women is related to male-like body appearance changes.	.31	.06	.09	.72	.20	-.15	.15
15. The purchase of the nutritional supplement from the authorized dealer is the only proper guarantee that the supplement does not contain doping agents.	-.14	.76	.00	-.04	.02	-.03	-.11
16. Synthetic testosterone increases the quantity of erythrocytes and is therefore common in endurance sports.	-.11	.05	.77	-.03	.09	.01	.30
17. The use of testosterone derivates by women is related to male-like body appearance changes.	-.01	.58	.16	.00	-.13	.23	.43
18. When an athlete reports undergoing official medical treatment they cannot be tested for doping.	.24	.03	-.04	.33	.64	.09	.08
Expl.Var	2.13	2.12	1.47	1.44	1.71	1.70	1.40
Prp.Totl	.18	.11	.08	.08	.09	.09	.08

Table 3. Factor analysis for KSN (F – factor structure; Expl.Var. – explained variance; Prp.Totl – total percentage of the explained variance).

	F1	F2	F3	F4	F5	F6	F7
1. Proteins consist of amino acids.	-.36	-.22	.25	.42	.36	-.31	-.30
2. Carbohydrates are types of sugars and table sugar is basically a type of carbohydrate.	-.50	.21	.11	.22	-.19	-.18	-.29
3. Amino acids are only useful in endurance sports like the marathon, triathlon, or long-distance open water swimming.	-.70	.06	-.34	.13	.24	-.04	-.13
4. Isotonic drinks should be used only during the “dry-land” training, and avoided during the training in the pool (water).	-.04	.32	.44	.51	.07	.26	-.12
5. The negative side-effects of excessive sweating are best prevented by drinking pure water.	-.45	-.44	-.27	.38	-.21	.01	.04
6. Between training sessions and competitive trials a banana is a better choice than a sandwich.	.07	.62	.19	-.08	-.01	.17	-.09
7. After the competition day has finished, it is better to not eat for 4 hours afterwards.	-.32	-.35	.10	.29	-.28	.48	.31
8. Dark yellow urine is a sign of proper hydration of the body.	-.31	.50	.08	.11	-.54	-.02	.26
9. A banana has a lower glycemic index if it is green, and not dark yellow with spots.	-.18	.02	.04	-.51	-.24	.50	-.52
10. For the first meal after a competition chicken breast (white meat) and eggs are a better choice than pasta.	-.21	-.22	.75	.10	-.10	.05	-.19
11. Rice is a better “pre-competition" meal than high-quality steak.	-.41	-.33	.55	-.25	.15	.02	.19
12. Fresh fruit and vegetables are the best source of high-quality proteins.	-.50	.32	.02	.03	.38	.09	.41
13. Red meat and green vegetables are valuable sources of iron.	-.54	.09	-.11	-.32	.55	.28	-.05
14. During competitions and training in warm climates black tea can serve as beneficial sport drink.	-.26	.16	.38	-.44	-.15	-.49	.23
15. Dried fruit is an excellent source of carbohydrates.	-.46	.27	-.18	.01	-.18	-.27	-.32
16. Carbohydrate-loaded meals should be avoided before training and competition because they encourage urination and therefore dehydration.	-.38	.41	.03	.06	.12	.12	.15
17. Protein supplementation asks for an increased intake of water.	-.62	-.37	.04	-.41	-.13	-.09	.02
18. To prevent mineral loss due to menstrual cycle, excessive water intake is beneficial	-.76	-.02	-.32	-.02	-.24	.05	.05
Expl.Var	3.45	1.82	1.66	1.54	1.33	1.13	1.07
Prp.Totl	.19	.10	.09	.09	.07	.06	.06

Discussion

There are several important findings from this investigation. First, results showed significant differences between athletes’ and coaches’ KSN and KD scores where coaches scored better than their athletes. Second, the correlation between sociodemographic- and sport-factors, with the KD and KSN questionnaires show inconsistent relationships when observed for athletes and their coaches. These issues will be discussed further in the Discussion, but we will first briefly comment on study limitations and the reliability and validity of the applied questionnaires.

Study limitations

First, this investigation is based on subjects’ self-reports. It can be argued that subjects might not have told the truth, especially if they felt uncomfortable. However, we believe that the testing design (see Methods) and our experience from previous studies (Sekulic et al., 2010; Zenic et al., 2010) decreased this possibility. Second, we must note that this study relies on a relatively small number of subjects sampled from only two countries. However, because previous studies addressing SUM issues in sports noted the importance of a high proportion of respondents (Modric et al., 2011; Sekulic et al. 2009), we believe that the relatively small number of subjects did not significantly affect our conclusions. Also, we studied nearly 100% of all competitive synchro athletes and their coaches in both countries, which we observe as more important than studying for example larger sample but which would not represent significant proportion of subjects of interest.

Reliability and validity of the applied questionnaires

Although parts of this questionnaire were used previously and found to be reliable (Sajber et al 2013b), prior to this study the questionnaire was checked for its clarity and content validity by two experts in the field of synchronized swimming (authors of this paper). The questionnaires we utilized have a high reliability, not only because of the high test-retest correlation values but also because of the percentage of the same answers on the test and retest.

However, the highest reliability was found for the first part of the questionnaire (socio-demographic, educational, sport factors etc.) where we have evidenced almost 100% of identical answers throughout test and retest. The reliability of the second part of the questionnaire (i.e.

Table 4. **Educational, sport nutrition and doping factors among athletes and coaches (F – frequency; % - percentage; Number in parentheses presents ordinal values for each answer).**

	Athletes		Coaches	
	F	%	F	%
Education				
Primary school (1)	11	13.41	-	-
High school (2)	49	59.76	1	3.57
Student (3)	20	24.39	8	28.57
College/University degree (4)	2	2.44	19	67.86
Primary source of information on sport nutrition and doping				
I have no knowledge about it	11	13.41	2	7.14
Coach	17	20.73	1	3.57
Formal education	29	35.37	6	21.43
Self-education	25	30.49	19	67.86
Doping in synchro				
I don't think doping is used (1)	23	28.05	8	28.57
Don't know, not sure (2)	42	51.22	10	35.71
Used rarely (3)	14	17.07	6	21.43
Used frequently (4)	3	3.66	4	14.29
Doping likelihood *(Coaches: Opinion of doping usage)*				
I do not intend to use doping (1) (Coaches: I will not suggest doping usage)	51	62.20	20	71.4
Don't know, not sure (2)	17	20.73	5	17.9
I'll use it if it will help me with no health hazard (3) (Coaches: I'll suggest it if convinced that it will help with no health hazard)	13	15.85	3	10.7
I'll use it if it will help me (4) (Coaches: I'll suggest doping usage if convinced that it will help my athletes to achieve the competitive goal)	1	1.22	-	-

Number in parentheses presents ordinal values for each answer

knowledge on nutrition and doping) is somewhat lower, where test and retest scores differed significantly both for KSN and KD (i.e. scores trended higher). However, this is a logical consequence of subjects that are interested in the topics of sports nutrition, NS and doping; therefore, we expect that many of the participants tried to improve their knowledge between the two test trials, regardless of our instructions to restrain from learning more about the test topics. The latent factor structures of the KD and KSN questionnaires are not clearly identified, but this is a common problem in questionnaire design. In short, empirically identified factors may not be theoretically meaningful because the identified factors may result from either method effect or response sets, rather than from differences in the underlying conceptual interpretations by the respondents (Sapp and Jensen, 1997). In such cases, it is hard to observe a logical and interpretable factor structure; however, this does not necessarily result in the non-validity of the questionnaire but suggests that the validity should be tested using the discriminative value of the analyzed tool (e.g., defining differences between groups).

KSN and KD scores among athletes and coaches

The knowledge on doping and knowledge on sport nutrition are higher among coaches than among their athletes. On the surface, these findings do not agree with

Table 6. **Correlations between studied variables among athletes and coaches (* denotes significant correlation coefficients).**

		Experience	Education	Sport achievement	Doping in synchro	Doping likelihood	KD	KSN
Education	**Athletes**	.58 *	-					
	Coaches	.26	-					
Sport achievement	**Athletes**	.25 *	.17	-				
	Coaches	.23	.27	-				
Doping in synchro	**Athletes**	.01	-.06	-.17	-			
	Coaches	.14	.09	-.27	-			
Doping likelihood	**Athletes**	-.11	-.19	-.25 *	-.01	-		
	Coaches	.03	-.10	-.07	-.25	-		
KD	**Athletes**	.38 *	.31	.01	.21	-.52 *	-	
	Coaches	.46 *	.23	.20	.61 *	-.17	-	
KSN	**Athletes**	.32 *	.24	.12	.00	-.20	.66 *	-
	Coaches	.17	.49 *	.00	.30	-.39	.29	-
Age	**Athletes**	.73 *	.81 *	.19	.04	-.19	.39 *	.36 *
	Coaches	.02	.27	-0.32	.17	-.04	-.13	.13

LEGEND: Experience – experience in synchronized swimming (in years); Education – educational level achieved; Sport achievement – achieved competitive sport result; Doping in synchro – personal opinion about doping behavior in synchronized swimming; Doping likelihood – potential doping behavior; KD – knowledge on doping; KSN – knowledge on sport nutrition; Age – subject's age.

the previous study results of Croatian synchro athletes who declared little trust in their coaches and their competence regarding NS and doping (Zenic et al., 2010). To explain this disagreement, we investigated the results in greater detail and calculated the KD and KSN results separately for Croatian (CRO) and Serbian (SER) athletes and coaches, whereas the previous study examined CRO athletes exclusively. In short, the results of the additional analyses showed that the KD score of the SER coaches was significantly higher than that of their CRO colleagues (8.12 vs. 5.80 for SER vs. CRO coaches, respectively). In addition, the CRO athletes have greater doping knowledge than do their SER peers (5.72 vs. 4.07 for CRO vs. SER athletes, respectively). Finally, when we compared KD scores for the CRO sample only, there was no significant difference between the coaches and athletes (5.72 vs. 5.80 for CRO athletes vs. CRO coaches, respectively). There are several possible reasons for the higher scores on the KD questionnaire by the SER coaches and CRO athletes. The primary reasons are that the SER coaches are older (34 years vs. 29 years, on average, for SER vs. CRO, respectively) and they are significantly more experienced in coaching (11 years vs. 7 years for SER vs. CRO, respectively). Most likely, the time spent in the sport allowed these coaches to improve their knowledge through non-formal communication and self-education (two of three coaches declared self-education as the primary source of information for sports nutrition and doping). On the other hand, our additional analysis showed that Croatian athletes participate in more international competitions, which is a factor previously demonstrated to be important in athletes' overall knowledge about other factors related to training and performance, such as nutrition, doping, training methodology, equipment, etc. (Dolan et al., 2011; Pipe, 2011). Consequently, the Croatian synchro athletes previously studied (Zenic et al., 2010) had objectively determined the relative lack of knowledge about sports nutrition and doping by their coaches.

Correlates of the KSN and KD among athletes and coaches

For athletes, both the KD and KSN scores are numerically low but significantly correlated to the age-dependent variables we measured (i.e., age, education, and sports experience). Although we did not find any studies that have investigated the relationship between age-dependent variables and doping knowledge, there are studies that confirm that nutrition knowledge is higher among older, more experienced athletes (Spendlove et al., 2012). Moreover, investigators have regularly reported non-significant relationships between formal education and knowledge on sport-nutrition among athletes (Nichols et al., 2005; Pessi & Fayh, 2011). However, we cannot absolutely agree or disagree with the latter findings of our respected colleagues. More precisely, our results showed a significant positive correlation between formal education with KSN and KD (i.e. more educated athletes scored better), but for a moment we cannot define should better knowledge be judged as a direct consequence of the advanced formal education, or the advanced formal education is a result of advanced age (i.e. age is a confounding factor) (Huck, 2004). Nevertheless, it is clear that younger synchro athletes should devote much more attention to sports nutrition and doping, especially because the athletes who scored higher on the KD questionnaire are less prone to future doping behaviour (see further discussion).

The amount of formal education of the coaches is significantly correlated to their KSN. In this particular case, the confounding age-effect on education status is not likely because the age of the coaches and the KSN score are not significantly correlated.

More experienced synchro coaches scored higher on the KD questionnaire. Most likely, coaches with more sports experience had greater awareness of doping-related topics (e.g., testing procedures, anti-doping regulations, negative health effects of doping, etc.). The authors of this paper are employed by three different universities in the territory of the former Yugoslavia and are familiar with the sports-education curricula. We postulate that there is no relationship between sports experience and KSN among coaches because sports nutrition has not been systematically taught in these universities until recently which directly influenced the results of the older coaches observed in this study. As a result, the younger (less experienced) coaches have advanced formal education on this topic. Conversely, older coaches (more experienced) may have improved their KSN non-formally, which led to a non-systematic relationship (i.e., null correlation) between sports experience and KSN. These findings are consistent with the recent ones when authors studied swimming athletes and their coaches on the same topic (Sajber et al., 2013b)

One of the most important findings of this study is that the athletes' KD score is significantly related to self-declared avoidance of doping in the future. Mainly, those athletes who are more aware of the doping-problems, including doping health-hazards are more negatively oriented to potential doping behavior in future. Because of the fewer subjects, the coefficient of the correlation between same variables was not statistically significant for coaches, although its numerical value shows similar trend. Since we have studied only self-declared intention for doping usage, and not doping usage per se, we cannot conclude with certainty that there is a protective effect of KD on doping behavior. But, the synchro athletes who are more aware of doping health-hazards may be less at-risk for doping behavior in the future. Taken together, our data reinforce the need for systematic education on doping and doping-related topics in synchro.

Conclusion

According to the results presented and discussed in this paper, the following conclusions can be drawn. Applied questionnaires are reliable instruments for establishing the level of knowledge of specific sports nutrition and doping among synchro athletes and coaches. We have proven the discriminant validity of the questionnaires because the coaches scored higher than the athletes on both of the measuring tools (KSN and KD), and the age-dependent variables (age, education, and sports experience) are significantly correlated to the athletes' scores on both ques-

tionnaires.

Although the coaches scored better than their athletes, we have found evidence that the level of the coaches' knowledge must be improved. We advocate improving the knowledge of sports nutrition among older coaches and the knowledge of doping among younger coaches. It is particularly important knowing that most of the coaches declared self-education as the primary source of information on sport nutrition and doping. Among athletes, younger swimmers should be targeted because we found systematically lower doping and sports nutrition knowledge among these athletes.

Because our results show that knowledge of doping and doping-health hazards are negatively related to potential doping behavior in the future, intervention strategies aimed at the improvement of doping knowledge are particularly important.

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Key points

- Although most of the synchro coaches are highly educated, self-education is declared as the primary source of information about doping and sport-nutrition.
- The knowledge of doping and doping-health hazards are negatively related to potential doping behavior in the future among synchronized swimmers
- The data reinforce the need for systematic educational programs on doping and sports nutrition in synchronized swimming.
- We advocate improving the knowledge of sports nutrition among older coaches and the knowledge of doping among younger coaches, while among athletes, younger swimmers should be targeted

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