©Journal of Sports Science and Medicine (2013) **12,** 290-297
http://www.jssm.org

Research article

Sport Nutrition and Doping in Tennis: An Analysis of Athletes' Attitudes and Knowledge

Miran Kondric [1]✉, Damir Sekulic [2,3], Ognjen Uljevic [2], Goran Gabrilo [2] and Milan Zvan [1]
[1] Faculty of Sport, University of Ljubljana, Ljubljana, Slovenia; [2] Faculty of Kinesiology, University of Split, Split, Croatia; [3] NIHON doo, Split, Croatia

Abstract
Nutrition and doping issues are rarely studied in the sport of tennis. The aims of this investigation were to determine knowledge on doping (KD) and knowledge on sport nutrition (KSN), and corresponding socio-demographic-, sport-, and sport-nutrition- and doping-factors among an international sample of high-level tennis players of both sexes (43 females; 22 years old on average). In the first phase of the investigation, the KSN and KD questionnaires were studied for their reliability and validity. The consumption of NS is found to be very high, with almost of all the females and 80% of the males using NS at least occasionally. The athletes showed a low tendency regarding future doping usage, although most of them are convinced that doping does exist in tennis. Since athletes declared that their coaches are their main source of information about NS and doping, future studies should investigate what coaches actually know about such problems. KSN has been found to be protective against potential doping behavior in the future. Males are found to be more prone to doping than females. Therefore, in order to prevent doping behavior in tennis we strongly suggest intensive educational programs on sports nutrition and doping-related problems.

Key words: Dietary supplementation, substances, reliability, validity, test.

Introduction

Proper nutrition has a direct influence on optimizing the human body's energy stores (Garcia-Roves et al., 2000), some nutritional approaches can reduce fatigue (Bonci, 2011; Davis, 1995), adequate nutrition and hydration is observed as one of the most important factors to prevent injuries (Silva et al., 2003), some kinds of nutrition can promote recovery from injuries (Guest and Barr, 2005; Moran et al., 2012), while nutrition directly influences athletes' health status (Nimmo and Ekblom, 2007; Venkatraman and Pendergast, 2002). Not surprisingly, in contemporary sports, nutrition is considered as one of the key optimizing factors in overall development of the athlete. However, it is likely that, for various reasons, not all athletes are able to consume a diet that meets their nutritional needs. Consequently, nutritional supplementation (NS) is considered as additional support for regular nutrition. In general, NS describes preparations intended to supplement the diet and provide nutrients such as vitamins, minerals, fiber, fatty acids or amino acids that may be missing or may not be consumed in sufficient quantities in a person's diet. The overall percentage of NS users in sports ranges from 60% to 93% (Braun et al., 2009; Dascombe et al., 2010; Heikkinen et al., 2011; Huang et al., 2006; Petroczi and Naughton, 2008; Ronsen et al., 1999; Striegel et al., 2006). Yet NS are only effective if they are properly consumed and it is known that the excessive use of NS and polypharmacy has been connected to serious health problems (Borrione et al., 2008; Petroczi et al., 2007). Consequently, authors have already noted the need to assess athletes' knowledge of these issues (Zenic et al., 2010; Kondric et al 2011).

When all factors, including NS, fail to provide the result athletes are striving for, the temptation to start doping emerges (Laure and Binsinger, 2005). In its most common sense, doping is defined as the occurrence of one or more anti-doping code violations, mostly observable in the presence of a prohibited substance or its metabolites or markers in an athlete's specimens (WADA). The practice of doping is often related to serious health problems (Deshmukh et al., 2010; van Amsterdam et al., 2010) and even death (Furlanello et al., 2007), but the problem is not "only" health-related. More precisely, doping is considered an unethical and unfair practice which allows one to go beyond natural genetic potential and therefore leads to an unfair advancement in an athlete's natural physical and physiological ability (Cavar et al., 2012; Ozdemir et al., 2005; Sekulic et al., 2008)

Tennis is one of the most popular sports today. It is estimated that almost 60 million players are involved in some kind of tennis competition at the local, national, and/or international level. The world of tennis is very concerned about the problem of doping in the sport. Concern has grown even stronger since 1988 when tennis was re-included in the Olympic Games program, but to the best of our knowledge only one study investigated the problem of doping in tennis, reporting the incidence of doping behaviors in this sport (Maquirriain, 2010).

Therefore, the aims of this investigation were to: were to determine knowledge on doping (KD) and knowledge on sport nutrition (KSN), and to study possible associations between KSN and KD with corresponding socio-demographic-, sport-, and sport-nutrition- and doping-factors among an international sample of high-level tennis players of both sexes. For this purpose, we designed and validated a questionnaire seeking to provide evidence of knowledge concerning: (a) nutrition and nutritional supplementation (KSN); and (b) doping issues (KD).

Methods

Sample and testing design

Received: 27 August 2012 / Accepted: 30 November 2012 / Available online: 04 April 2013 / Published: 01 June 2013

Before the main study with the total sample, we have done pilot study to determine the reliability and validity of the KD and KSN questionnaires. In this part of the experiment we have included 15 subjects who were tested within a timeframe of 10 days using a test-retest procedure for both questionnaires. The sample of subjects included in main study consisted of 65 high-level tennis players, of whom 43 were females (21.6 ± 2.7 years); and 21 were males (23.2 ± 2.8 years); all from the 11th to 16th levels according to the Universal Tennis Rating. Participation was anonymous with no personal data being collected regarding date of birth, city of residence etc. Although we did not ask the participants to note their country of origin (hence we cannot connect any personal results to the country of origin), we note that we included athletes from 13 European countries, the USA, Thailand and Brazil in the testing. The participants were tested on three ITF tournaments held in Europe from January to April 2012. The answer options were presented as multiple-choice closed responses for all questions. The respondents were tested in groups of at least three. Each respondent was informed that the survey was strictly anonymous, they could refuse to participate and they could leave some of the questions and/or the entire questionnaire unanswered. The response rate was over 99%. The study complied with all ethical guidelines and received the approval of the Institutional Ethical Board.

Variables

The sample of variables included sociodemographic factors, sport factors, sports nutrition factors, doping-related factors, KSN, and KD.

The sociodemographic variables included sex, age, educational level achieved (a four-point scale from primary school to university degree).

Sport factors consisted of questions asking participants about the sport result achieved as a junior (a three-point scale: national-level championship, national team, ETA/ITF), and senior (a four-point scale: never competed on the senior level, national-level championship, ITF senior tour, ATP/WTA tour).

Sport-nutrition part of the questionnaire included questions about current NS practice (possible responses were "Yes", "From time to time", and "No") trust in their coach regarding NS and trust in their physician regarding NS (both "Yes/No" questions). Finally, we asked the athletes who was their primary source of information about nutrition issues (possible answers included coach, physician, formal education, self-education, and I have no knowledge).

Doping-related factors were studied through questions about the athlete's opinion about doping practices in tennis (a four-point scale from "I do not think doping is used" to "Doping is often used"); potential doping habits (a four-point scale from "I do not intend to use doping" to "I'd use it if assured it would help me"); trust in their coach regarding doping and trust in their physician regarding doping (both "Yes/No" questions); the number of times the participant has undergone doping testing (a four-point scale from "Never" to "More than five times"); and personal opinion on the penalties for doping offenses (a five-point scale from "Doping should be allowed" to "Lifelong suspension").

The KSN and KD were measured using the originally constructed questionnaires. Prior to the testing, a panel of professional and scientific experts within the field of sport nutrition and doping (including academics and professionals from the National Anti-Doping Agency) were consulted to construct a clear and understandable questionnaire which would be sport-specific to some extent, while being problem-oriented and valid at the same time. Both questionnaires consisted of 18 questions. Each question (statement) was in a "true or false" form where, in the case of a correct answer, the subjects scored one point and zero otherwise. Following a preliminary factor analysis, the retained items were summed separately for KSN and separately for KD, leading to a potential 0–18 range for the KD, and a 0–17 range for the KSN questionnaires (see the Results for more details of the differences between the ranges). All of the questions are presented in Tables 2 and 3.

Statistical analysis

Pearson's coefficient of the linear test-retest correlation and the percentage of equally responded queries were used as measures of reliability for KSN and KD. Also, we calculated dependent samples t-test to evidence stability of the KD and KSN with regard to potential learning effects between test and retest.

To determine the construct validity of the KSN and KD two exploratory factor analyses were carried out using the principal component analysis extraction method (Gutman Kaiser Criterion of extraction) and a Varimax rotation. The exploratory factor analysis suggested which items should be deleted, and also constructed the factors for the scale. A factorial load of 0.50 was chosen as the cut-off point and items with a factorial load below this value were excluded.

Depending on the parametric/nonparametric nature of the variables the means and standard deviations (for parametric) or counts (frequencies) and proportions (for nonparametric) were calculated. Analysis of variance (for parametric variables) and a nonparametric Kruskal-Wallis ANOVA test (for non-parametric variables) were applied to establish differences between genders in the studied variables.

To determine any associations between the variables Spearman's rank-order correlation was calculated. The statistical significance level of 95% ($p < 0.05$) was applied. Statistical analyses were carried out using Statsoft's Statistica Version 10.

Results

The test-retest correlations are high for KSN (0.91) and KD (0.87), while the tested subjects equally responded to 89% (KSN) and 87% (KD) of all queries. T-test showed significant ($p < 0.05$) learning effects between test and retest (5.33 ± 2.77 vs. 6.20 ± 2.46 and 8.33 ± 2.69 vs. 9.13 ± 2.77 for KD and KSN respectively). Both exploratory factor analyses extracted six significant factors, while the models explained 65% (for the KSN) and 77% (KD) of

the variance (Table 1 and 2). We had initially decided to use 0.50 of the factor loading as a cut-off point and therefore the first question of the KSN questionnaire was excluded from further analysis. Consequently, the theoretical range for the KD was 0–18 points (i.e. all originally constructed questions were retained), and for the KSN it was 0–17 points (one question was omitted after performing the factor analysis). For the moment, we can generally name the latent variables obtained for KD as: "doping control regulation 1"; "doping control regulation 2"; "steroids and testosterone"; "EPO"; "overall doping knowledge"; and "human growth hormone". However, the factor structure for the KSN does not allow a meaningful interpretation of the factors. That is, the items with factor loadings do not show a consistent pattern related to different nutrients (carbohydrates, proteins etc.), and/or other topics (hydration, vitaminization etc.).

Females are more advanced in their competitive (sport) achievement (Table 3). The consumption of NS is high, with practically all the females self-reporting their use of NS, while 20% of the males do not use NS (Table 4). The likelihood of doping behavior is low and men are more prone toward potential doping behavior in future. Most of the athletes trust their coaches and physicians about nutritional and doping issues, and declared that their coaches are their primary source of information on this matter (Table 5).

Although the males achieved numerically higher scores than the females for both questionnaires (9.67 ± 3.69 vs. 8.81 ± 2.96, and 8.00 ± 3.67 vs. 6.72 ± 2.68, for KSN and KD respectively), an analysis of variance found no significant differences ($p > 0.05$) between the genders.

Among females, the KD and KSN scores are significantly correlated to formal education, with KD correlating to the number of doping tests while those who achieved a higher result for the KD score are more convinced about the use of doping in tennis. Those girls who scored higher for KSN showed a lower tendency to engage in potential doping behavior in the future (Table 6) The correlations showed that older males are more convinced about the use of doping in tennis. Age is positively correlated with KD and KSN. Those who achieved a higher result at senior level are more convinced about doping behavior in their sport and are simultaneously negatively oriented to potential doping habits in the future. The KSN is negatively related to potential doping behavior among males also. However, we must note that the trends of correlations for the males and females do not differ considerably, and the smaller number of male participants negatively influenced the level of significance of the calculated coefficients and some coefficients therefore did not reach the appropriate level of statistical significance among the males (Table 6).

Table 1. Factor validity of the knowledge on doping questionnaire (F – factor structure; FV – factor variance; PT – proportion of the explained variance).

	F1	F2	F3	F4	F5	F6
Caffeine is considered to be doping if its concentration in urine exceeds a certain level.	.21	.25	.26	.55	.11	.02
Erythropoietin (EPO) is a doping substance used in strength-and-power sports (e.g., weightlifting).	.38	-.47	.12	.64	.34	.16
If sample A is positive for doping, an athlete is entitled to ask for the sampling of another one within 48 hours.	.82	.10	.11	-.25	-.32	.11
Doping control officers should notify athletes of their testing intentions a few hours prior to any testing.	.87	.00	.02	.01	-.24	-.08
If an athlete has an out-of-competition doping control, four weeks should elapse before the next doping control.	.11	.87	-.20	-.04	-.08	-.24
If a doping control officer does not provide valid proof of identity an athlete can refuse to participate in the testing.	.33	.76	.17	-.25	-.13	-.32
Anabolic steroids used during puberty have neither positive nor negative effects.	.25	.05	.51	.09	.02	.08
The use of human growth hormone is related to azoospermia.	-.07	.07	.04	.07	.05	-.89
In the case of asthma. I can use some drugs which are regularly included in the doping-list.	.68	.24	-.33	.07	.27	-.18
A "masking agent" is someone who helps an athlete hide their use of doping and is therefore equally responsible for doping offenses.	.69	.01	-.06	-.16	-.88	.12
EPO is detected in blood samples.	.35	.14	.12	.88	.04	.19
A person caught with material evidence of EPO (for example. ampules containing EPO) can be charged as a doping-offender.	.25	.17	.27	.66	.09	.23
The use of amphetamines has been related to several cases of death in cycling due to cardiovascular failure.	.11	-.04	-.15	-.05	.71	-.03
The use of amphetamines by women is related to male-like body appearance changes.	.28	-.30	.07	-.30	.50	.23
The use of EPO is also known as "blood doping".	-.16	.28	.51	.35	.14	.06
Synthetic testosterone increases the quantity of erythrocytes and is therefore common in endurance sports.	-.29	.08	.69	.11	.25	.07
Synthetic testosterone use inhibits the production of natural (endogen) testosterone.	.20	.24	.89	.02	-.09	.17
When an athlete reports undergoing official medical treatment they cannot be tested for doping.	.14	.14	-.27	-.47	.76	-.32
FV	3.19	1.99	2.26	1.87	2.60	1.33
PT	.18	.11	.13	.14	.14	.07

Table 2. Factor validity of the knowledge on sport nutrition questionnaire (F – factor structure; FV – factor variance; PT – proportion of the explained variance).

	F1	F2	F3	F4	F5	F6
Proteins consist of amino acids.	-.01	-.02	.00	-.40	.25	.02
Carbohydrates are types of sugars and table sugar is basically a type of carbohydrate.	.15	-.03	.08	-.31	.05	.80
Amino acids are only useful in endurance sports like the marathon or triathlon.	.18	.47	.51	.00	-.09	.52
Isotonic drinks should be avoided in an extremely hot environment (temperatures above 35 degrees Celsius).	.75	.34	.04	.31	-.25	.06
The negative side-effects of excessive sweating are best prevented by drinking pure water.	-.05	-.23	-.29	-.14	.75	.36
Between tennis sets a banana is a better choice than an apple.	.30	.03	-.05	.43	.07	.73
After the competition day has finished, it is better to not eat for 4 hours afterwards.	.15	-.05	.20	.24	-.14	.80
Dark yellow urine is a sign of proper hydration of the body.	.69	.00	.21	-.32	.13	.54
A banana has a lower glycemic index if it is green, and not dark yellow with spots.	.66	.21	.29	-.19	.13	.38
For the first meal after a match, chicken breast (white meat) and eggs are a better choice than pasta.	.13	.22	-.18	.54	.58	-.34
White rice is a better “pre-match” meal than wholemeal pasta.	.62	.01	-.03	-.24	.45	-.53
Fresh fruit and vegetables are the best source of high-quality proteins.	.72	-.14	.08	.32	.14	.33
Egg yolks and poultry are a valuable source of vitamins B and C.	.02	-.62	.26	.51	.06	.28
During competitions in warm climates black tea can serve as beneficial sport drink.	-.02	.16	.91	.13	.06	.10
Dried fruit is an excellent source of carbohydrates.	.23	-.05	.86	.02	-.05	.10
Carbohydrate-laden meals should be avoided before matches because they encourage urination and therefore dehydration.	.12	.18	.26	-.12	.81	-.14
Protein supplementation asks for an increased intake of water.	.12	.86	.20	-.03	.12	.05
During journeys in which the time zone changes. it is better to avoid vitamins and herbal supplements since they can cause nausea and insomnia.	.01	-.23	.19	.68	.05	.24
FV	2.64	1.74	2.34	1.95	2.00	3.34
PT	.15	.10	.13	.11	.11	.19

Discussion

The results presented so far allow a broad discussion of the findings. However, we will mostly focus on certain problems we deemed particularly important with regard to the study aims and problems which had previously not been so extensively studied in tennis. Therefore, for the purpose of this investigation we are chiefly concentrating on: 1) the consumption of NS and related factors; and 2) attitudes to doping. Before discussing such problems, we will briefly overview the reliability and validity of the applied questionnaires.

When compared to the results of similar studies which dealt with the reliability of questionnaire tools (Dvorak et al., 2008; Zinn et al., 2005), there was an evident high reliability of KD and KSN not only with regard to the test-retest correlation, but also the percentage share of equally responded queries. But, there is evident trend of achieving higher numerical scores in the retest. It is logical since all subjects were advanced athletes and it is reasonable to expect that all of them will try to improve their knowledge between two test trials regardless to our instructions of keeping restrain from consulting on the topics they have been tested. Although the latent structure of the KSN was not clearly identified (i.e. we could not precisely name the latent dimensions), it is a common problem in questionnaire design (Sapp and Jensen, 1997). In such cases, it is suggested that the validity should be tested using the discriminative value of the analyzed tool (i.e. correlating formal education to the questionnaire score, for example). Since correlation analysis showed a significant correlation between the formal education level

Table 3. Sociodemographic and sport characteristics (F – frequency; % - percentage) and differences between genders (KW – Kruskal Wallis test).

		Females		Males		
		F	%	F	%	KW
Education	Elementary school (1)	0	0.0	0	0.0	
	High school (2)	27	62.8	7	33.3	
	Student (3)	8	18.6	11	52.4	2.54
	Graduated (4)	8	18.6	3	14.3	
Level achieved as junior	National level championship (1)	2	4.7	6	28.6	
	National team (2)	2	4.7	1	4.8	6.12*
	ETA/ITF (3)	39	90.7	14	66.7	
Level achieved as senior	Never competed on a senior level (1)	3	7.0	4	19.0	
	National level championship (2)	0	0.0	5	23.8	
	ITF senior tour (3)	0	0.0	2	9.5	14.83*
	ATP/WTA tour (4)	40	93.0	10	47.6	

Table 4. Sport nutrition factors (F – frequency; % - percentage) and differences between genders (KW – Kruskal Wallis test).

		Females		Males		
		F	%	F	%	KW
Consumption of the nutritional supplements (NS)	Yes (1)	13	30.2	7	33.3	
	Yes. but not regularly (2)	30	69.8	9	42.9	
	No (3)	0	0.0	4	19.0	1.02
	Missing	0	0.0	1	4.8	
Trust in coaches regarding NS	Yes	29	67.4	12	57.1	
	No	14	32.6	8	38.1	
Trust in physicians regarding NS	Yes	31	72.1	13	61.9	31
	No	12	27.9	7	33.3	12
	Missing	0	0.0	1	4.8	0
Primary source of information on nutrition and NS supplements	I have no knowledge on this problem	5	11.6	2	9.5	
	Coach	24	55.8	12	57.1	
	Formal education (school, professional seminars. etc.)	14	32.6	5	23.8	
	Self-education (internet, literature, etc.)			2	9.5	

Number in parenthesis present ordinal value for each answer

and both questionnaire scores (KD and KSN), the validity of the KSN should be judged as adequate even though we could not meaningfully name the isolated latent dimensions.

The higher incidence of NS usage among the females is expected (Braun et al., 2009; Dascombe et al., 2010; Huang et al., 2006; Ronsen et al., 1999; Striegel et al., 2006), and such findings are largely explained by a higher awareness of increased nutritional needs in sport, but also by females having more of a real need for supplements (e.g., the consumption of extra minerals to compensate for menstrual loss).

Studies repeatedly reported that athletes have a high level of trust in their coaches regarding nutritional supplementation and doping (Sundgot-Borgen et al., 2003; Torres-McGehee et al., 2012). In our case it is probably even more justified being aware of the characteristics of the studied subjects. Briefly, in this study we sampled "tour tennis players", meaning those athletes who are most of the time "out of home", chiefly living and training in training camps, and participating in tournaments. In such situations, athletes and coaches are strongly connected throughout the complex process of engaging in a competitive sport. Yet, as much as coaches can provide valuable support for overall athlete development, they can cause serious damage if they are not properly informed and educated.

Males are more susceptible to potential doping behavior than females. In general, such findings are expected since it is known that female athletes are less oriented to substance misuse (including doping) than their male peers (Irving et al., 2002; Lorente et al., 2005), and differences of this kind have recently also been reported for positive doping-findings in tennis (Maquirriain, 2010). But, the results presented here show a relatively low doping likelihood in the studied sample. This is even more intriguing given that most of the studied athletes believe that doping does exist in the sport of tennis, whereas believing in the occurrence of doping in sport has been found to be the key predictor of future doping behavior in several sports and activities, including racket sports (Kondric et al., 2011; Rodek et al., 2009; Sekulic et

Table 5. Doping factors (F – frequency; % - percentage) and differences between genders (KW – Kruskal Wallis test).

		Females		Males		
		F	%	F	%	KW
Testing on doping	Never (1)	35	81.4	20	95.2	
	Once or twice (2)	4	9.3	0	0.0	
	2-5 times (3)	2	4.7	0	0.0	1.98
	More than 5 times (4)	2	4.7	1	4.8	
Trust in coaches regarding doping	Yes	15	34.9	7	33.3	
	No	28	65.1	14	66.7	
Trust in physicians regarding doping	Yes	28	65.1	14	66.7	
	No	15	34.9	7	33.3	
Doping in tennis	I don't think that it is used (1)	9	20.9	1	4.8	
	Don't know - not familiar (2)	14	32.6	4	19.0	
	It is used but rarely (3)	12	27.9	14	66.7	2.3
	Doping is often (4)	8	18.6	2	9.5	
Personal opinion about penalties for doping offencers	Lifelong suspension	8	18.6	3	14.3	
	First time milder punishment. second time - lifelong suspension	32	74.4	13	61.9	
	Suspension for couple of seasons	1	2.3	4	19.0	
	Financial punishment	2	4.7	1	4.8	
	Doping should be allowed	0	0.0	0	0.0	
Potential doping habits	If assured it will help me no matter to health hazard (1)	1	2.3	0	0.0	
	I will use it if it will help me with no health hazard (2)	1	2.3	4	19.0	
	Not sure about it (3)	3	7.0	4	19.0	5.93*
	I do not intend to use doping (4)	38	88.4	13	61.9	

Number in parenthesis present ordinal value for each answer; * $p < 0.05$

Table 6. Spearman's rank order correlations between studied variables for females (F) and males (M).

		CR Jun	CR Sen	NS use	Doping testing	Doping in tennis	Doping likelihood	KD	KSN
Age	F	-.30	-.17	.44 *	.37 *	.11	-.28	.56 *	.31 *
	M	-.38	.37	.19	.33	.79*	-.48 *	.49 *	.49 *
CR Sen	F	.57 *							
	M	.39							
NS use	F	-.21	-.18						
	M	-.62 *	-.19						
Doping testing	F	-.26	-.14	-.30 *					
	M	-.34	-.16	.39					
Doping in tennis	F	-.47 *	-.23	-.53 *	.25				
	M	-.37	.48 *	.31	.07				
Doping likelihood	F	-.12	.21	-.07	-.28	.17			
	M	-.28	-.55*	.12	-.36	-.41			
KD	F	-.08	.15	-.27	.31 *	.58 *	.08		
	M	-.05	.03	-.35	-.04	.41	-.06		
KSN	F	-.01	-.29	.17	-.04	-.11	-.47 *	.23	
	M	.06	.21	-.35	.24	.29	-.60 *	.80 *	
Education	F	-.52 *	-.23	.49	-.06	.10	.27	.40 *	.60 *
	M	-.61 *	.19	.32	.37	.50 *	-.05	.19	.06

Legend: Age – age of the subjects; Exper – sport experience; CR Jun – competitive achievement as junior; CR Sen – competitive achievement at senior competitions; NS use – usage of the dietary supplements; Doping testing – frequency of doping testing; Doping in tennis – personal opinion about doping in tennis; Doping likelihood – personal likelihood of doping behavior in future; KD – knowledge about doping; KSN – knowledge about sport nutrition; Education – level of formal education; * $p < 0.05$

al., 2010; Zenic et al., 2010). Our findings that less than 5% of the females studied show some tendency towards doping are somewhat lower than results previously reported for Slovenian racket sport female athletes (Kondric et al., 2011). Meanwhile, almost 20% of the males reported some tendency towards doping in the future, and this prevalence is practically identical to findings reported earlier for other racket sports (Kondric et al., 2011).

A significant determinant of the outcome of a tennis game is an individual's physical fitness, which can be influenced by their hydration and nutritional status (Lees, 2003). Therefore, knowledge of proper nutritional techniques and hydration (e.g. the timing of the consumption of different nutrients, adequate and precise hydration, adequate NS etc.) can positively affect a player's ability to train, play and recover from exercise. It increases the overall physical but also psychological capacities of athletes, which logically keeps them away from potential doping usage. It is directly supported in our results which evidenced lower likelihood of future doping behavior among those athletes who scored higher for KSN.

Among females KD and KSN are significantly correlated to formal education. Although we found no study which investigated the relationships between formal education and knowledge about doping, nutritional knowledge is known to be higher among people with more formal education (Sapp and Jensen, 1997). However, it is stated that formal education *per se* is not a predictor of knowledge about nutrition (i.e. such knowledge is not gained through formal education), but instead that people with more formal education are more inclined to have acquired formal or self-organized education concerning nutrition. The known differences between the sexes regarding the tendency toward formal and non-formal education (i.e. females are more prone to formal education; Boeren, 2011) can probably explain why we found no significant correlations between formal education and knowledge scores for the males.

Study limitations

The limitations of these results and the conclusions drawn from them arise mostly from the self-reported nature of the study, and the fact the subjects might not have told the truth, especially if they felt uncomfortable. However, we believe that the testing design (see Materials and methods), and the experience of previous studies reduced this possibility. In addition, there was some possibility that due to the testing design (with the testing being done on several occasions) the subjects had talked to each other and therefore made their colleagues at least partly familiar with the testing and questions. We were aware of this problem and sought to avoid it by testing the athletes within a short period of time. At the end, we believe that this study, although not the final word on the topic, should contribute to the field, especially given the evident lack of such investigations in the sport of tennis.

Conclusion

The incidence of NS use among the tennis players is found to be very high, especially among the females. Since we are unable to discuss it more precisely for the moment, it is very important that future studies investigate whether such NS consumption is justified, or whether athletes consume NS excessively.

The subjects in this study showed a low tendency regarding future doping usage, and reported high levels of trust in their coaches with regard to NS and doping. Although both findings are encouraging, it is important to note that males are more prone to potential doping behavior, while further studies should investigate what tennis coaches actually know about NS and doping. Knowing that knowledge about sport nutrition is found to be protective against potential doping behavior in both sexes, all

stated clearly reinforces the need to include a wide and systematic educational program on sports nutrition and doping in tennis.

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Key points

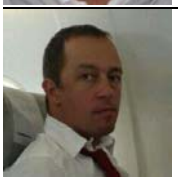
- The incidence of nutritional supplementation use among the tennis players is found to be very high, especially among the females.
- Although most of the subjects are of the opinion that the doping behavior is present in tennis circuit, we have found a low tendency regarding future doping usage, and high levels of athletes' trust in their coaches with regard to nutritional supplementation and doping.
- There are indices that the knowledge about nutrition is protective factor against potential doping behavior. It clearly reinforces the need to include a wide educational program on sports nutrition in tennis, but also in other sports.

AUTHORS BIOGRAPHY

Miran KONDRIČ
Employment
Associated professor. Faculty of Sport, University of Ljubljana, Slovenia.
Degree
PhD
Research interests
Motivation in physical education, sport and exercise; racket sports, substance use and misuse.
E-mail: miran.kondric@fsp.uni-lj.si

Damir SEKULIĆ
Employment
Full professor. Faculty of Kinesiology, University of Split, Croatia.
Degree
PhD
Research interests
Substance use and misuse, test construction and validation
E-mail: dado@kifst.hr

Ognjen ULJEVIĆ
Employment
Teaching assistant. Faculty of Kinesiology, University of Split, Croatia.
Degree
B Ed, Doctoral student
Research interests
Water polo, sailing, nutrition in sport
E-mail: ognjen.uljevic@kifst.hr



Goran GABRILO
Employment
Assistant Professor. Faculty of Kinesiology, University of Split, Croatia.
Degree
PhD
Research interests
Substance use, swimming, soccer
E-mail: goran.gabrilo@kifst.hr

Milan ŽVAN
Employment
Full professor. Faculty of Sport, University of Ljubljana, Slovenia.
Degree
PhD
Research interests
Motivation in physical education, sport and exercise; alpine skiing, sociology, doping.
E-mail: milan.zvan@fsp.uni-lj.si

✉ **Miran Kondric**
Faculty of Sport, University of Ljubljana, Gortanova 22, Ljubljana, Slovenia