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HYDRATION PRACTICE AMONG ATHLETES – DESIGN AND EVALUATION OF A QUESTIONNAIRE

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Abstract
The objective of this study was to design a reliable questionnaire regarding hydration practice among athletes. Participants were students recruited from the University of Split, Croatia. The questionnaire consists of 28 questions; gender, age, body mass and height, health status, years of training, weekly and daily length of training, intensity of training, hydration habits during training, etc. The same participants conducted the questioning twice, one month apart. In the eligibility and validation of each question, the Pearson correlation coefficient assessed the reproducibility of the quantitative data, while the corrected Cohen's *d* assessed the reproducibility of the qualitative data. Chi-square tested hypothesis (H_0=The data follow a specified distribution; in this study – no significant differences in the average answers (after one month) were established). The values for Pearson correlation coefficients should be as close as possible to 1 and the values for corrected Cohen's *d* should be as close as possible to zero. Pearson correlation coefficients ranged from 0.0625 (e. g. for amount of liquid amino acid intake) to 1 (e.g. for frequency of liquid amino acid intake prior to training). Reproducibility was accepted and chi-square confirmed our hypothesis.

Key words: Chi-square, Cohen's *d*, hydration, Pearson correlation, questionnaire

Introduction

To achieve fluid balance in the body and optimize performance, it is crucial for athletes to replace the water lost during physical activity (Šmuljić et al., 2016). Water intake recommendations for the general population are based on age, gender, as well as pregnancy and lactation in women, but do not cover the needs for liquid intake in conditions of extreme ambient and body temperature activities (European Food and Safety Agency [EFSA], 2010). Therefore, the recommended daily water intakes sufficient to cover the needs of moderate physical activity in moderate environment conditions for adult women and men are 2 L and 2.5 L, respectively (EFSA, 2010).
However, it has been recognised that the recommendations are often misunderstood (Maughan, 2015). Misinterpretation is apparent as it is believed that the recommendations refer only to the water intake in its pure form, while the recommended intake is actually the volume of water (2 L or 2.5 L) consumed through water itself, other beverages, and food (Maughan, 2015). Adequate hydration is one of the key factors that aid performance in many sports, especially if training and competition take place in a hot environment.
During physical activity, the body produces heat which raises core body temperature (Maughan & Shirreffs, 2008), and proper fluid intake during exercise or competition helps endurance performance (Sawka & Castellani, 2007). Dehydration negatively affects the quality of training and sport result during competition. It causes a reduction in blood volume and consequently lower delivery of oxygen and nutrients (including glucose) to the brain and muscles (Baranauskas et al., 2015). Therefore, it is generally advised to keep dehydration during training and competition under 2% of the initial body mass (Burdon, Johnson, Chapman & O'Connor, 2012).

In order to evaluate the hydration practice of athletes and, if necessary, to advise them on how to improve their habits, it is necessary to apply an appropriate questionnaire. To the extent of our knowledge, there is currently no questionnaire that is reliable and valid in assessing hydration practice before, during and after training, regarding the type, amount and temperature of drink(s), and the frequencies of intake in relation to gender, age, anthropometric values, type of sport, sport level, environmental conditions during training, source of information and advice regarding hydration. Therefore, a questionnaire was designed to investigate pre, during and post hydration and was validated.

Methods

Subjects

As previously advised, questionnaires should be pilot-tested on a smaller sample of participants (Saw & Ng, 2001). Therefore, we recruited seventeen participants: eight female and nine male participants from the Faculty of Kinesiology, University of Split, Croatia, aged from 20 to 22 years. These participants were selected due to guidelines that the subjects in a validation study should be a random sample of the study population in which the questionnaire will be applied (Klipsten-Grobusch et al, 1998); in this case, recreational and professional athletes. Participation in the study was voluntary. Institutional ethics approval was obtained (Approval number: 101/2016, Faculty of Kinesiology, University of Zagreb, 14 September 2016).

Study protocol

The TA pilot-questionnaire was designed according to the nature of the study, scientific data, and daily practices and habits of athletes regarding hydration. One of the authors (DK) collected the data. All data were collected during morning classes in the classroom, prior to sports classes in the field, according to Peters et al. (1993). The questionnaire was self-administered. Each participant completed the questionnaire twice; at least 1 month apart, as it was done in a previous study (Gerstein et al., 1999).

Questionnaire

The questionnaire has 28 questions arranged in five sections. The suggestions of Tsang, Royse and Terkawi (2017) were applied in formulating questions that should lead to reproducible answers.

The first section consists of the questions regarding sex, age, anthropometric values (height and mass for the calculation of the body mass index), type of sport, sports level, etc. In the second section, participants were asked to report the time and frequency of their drinking consumption, as well as the temperature and average amount of drinks consumed (before, during and after training sessions). The drinks selected for inclusion in the questionnaire were those that are most popular among the athlete population. In the final section, participants were asked to name their main source of information regarding hydration practice. The time frame was not specified, as liquid intake before, during and after training depends on many factors such as weather conditions, altitude, type and duration of training, possibilities for fluid ingestion, etc. Therefore, the respondents referred to their present practices.

Statistical analysis

In the validation of each question of the developed questionnaire, the degree of agreement between the answer given in the first and second sessions was determined. Statistical analysis was performed using the STATISTICA software (StatSoft, Inc., v10.0). The performance of the questionnaire was evaluated in terms of reproducibility evaluating the correlation and degree of agreement (DOA) between the first and second questionnaire session. Arithmetic means and standard deviations were calculated for age, anthropometric values and years of engagement in sport. The Pearson correlation coefficient was used to assess test-retest reliability on the scores of the participants who completed the questionnaire twice, as elsewhere (Turconi et al., 2003; Fernández-Ballart et al, 2010). Within-person's data variations between the first and second questionnaire sessions were revealed as the Cohen's *d* effect size, as in a previous study (Pedišić, Vranešić Bender & Mišigoj Duraković, 2008). Cohen's *d* is defined as the difference between two means divided by the standard deviation for the data. In an ideal situation, the statistical data of the two questionnaire sessions are the same, meaning that Cohen's *d* for parameters of interest magnitudes of $d = 0.01$ to 2.0 (Sawilowsky, 2009) where the effect size is not established ($d=0$),; very small for $d=0.01$-0.19; small for *d* in the range of 0.20 – 0.49; medium in the range of 0.50 to 0.79; large for *d*`s in range 0.80-1.19: Very large and huge is the effect size for *d*`s 1.20 and 2, respectively.

Results

The age of female participants was on average 20.88 ± 0.35 years and male participants were on average 20.78 ± 0.67 years of age. In a previous study (Das, Patra, Koley & Saha, 2017), it was acknowledged that the Chi-Square test can be used in an evaluation of study effectiveness as it represents the Chi-Square adequacy of well-designed tests. The Chi-Square test was used to compare the actual and expected range. The answer frequency range of the first questionnaire session was used as the expected range, while the answer frequency range of the second questionnaire session was used as the actual range. Questionnaire results were divided based on the provided information as the degree of activities (Table S1; questions 8-13); agreement of the answers related to their (i) sport, (ii) hydration before training (Table S2; questions 14-17); (iii) hydration during training (Table S3; questions 18-20); (iv) hydration after training (Table S4; questions 21-24) and (v) general hydration habits (Table S5; questions 25-28).

Correction of the parameter Cohen's *d* is needed based on the population data (<50) in the observed set. A negative Cohen's *d* occurs when the second measurement range is lower than the first, and such an example is presented in the results of this study (Figure 1).

Figure 1 Distribution of answers to the question "What is the dominant level of intensity in your trainings?", presenting the meaning of Cohen's *d*.

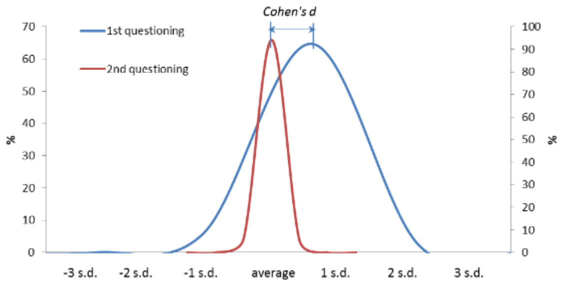

Figure 2 Temperature of consumed drinks after training presented as frequencies, with additional coefficient of correlation (Pearson) and degree of agreement (corrected Cohen's *d*).

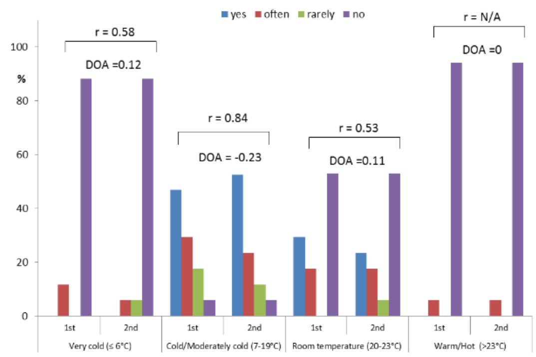

Figure 3 Results to the question "From whom have you received advice about hydration?" based on the values of the correlation coefficient (r) and corrected Cohen's *d* (DOA); question 28.

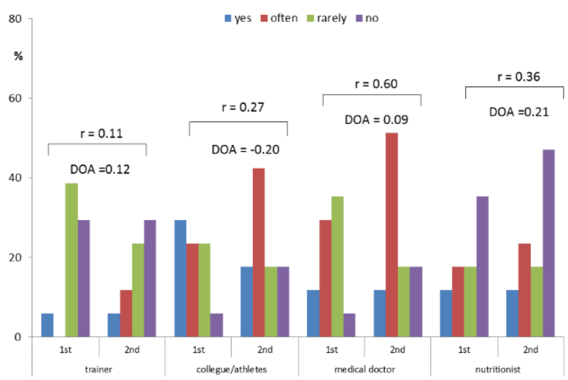

Table 1 Analysis of the degree of agreement for questions related to the sport activities of participants (answers related to number, intensity and durations of trainings)

Observed parameters	Pearson coefficient			Cohen's *d*		
	M	F	All	M	F	All
Years of sport engagement	0.980	1	0.987	-0.068	0.310	0.009
Description of competition level	0.982	0.987	0.980	0.086	-0.079	0
Number of training sessions per week	0.904	0.945	0.898	0	0.349	0.149
Physical activity per week (hours)	0.967	0.891	0.901	-0.213	0.46	0.063
Level of training	0.553	-0.079	0.442	-0.279	0	-0.184

**Correction is needed based on the population data in the observed set; M – males; F- females*

Table 2 Analysis of the degree of agreement for questions related to participants pre-training hydration

	Pearson coefficient	Cohen's *d* corrected	Chi square
Frequency: Water	n.d.	- 0.633	1.000
Frequency: Electrolytes	0.723	- 0.129	1.000
Frequency: Fruit juice	0.584	0.000	1.000
Frequency: Classic cola beverages	0.685	0.256	1.000
Frequency: Sweetened coffee	0.374	1.092	0.997
Frequency: Sweetened tea	0.664	0.359	1.000
Frequency: Energy drink	0.619	- 0.099	1.000
Frequency: Protein drink	0.394	- 0.262	0.980
Frequency: Carbohydrate drink	0.540	0.168	1.000
Frequency: Amino acid drink	1.000	0.000	1.000
Frequency: Another drink is taken	n.d.	- 0.619	0.913
Quantity: Water	0.588	- 0.070	0.999
Quantity: Electrolytes	0.540	0.577	0.998
Quantity: Fruit juice	0.959	0.290	1.000
Quantity: Classic cola beverages	0.586	0.168	1.000
Quantity: Sweetened coffee	0.272	- 0.136	0.990
Quantity: Sweetened tea	0.457	- 0.119	0.988
Quantity: Energy drink	0.901	0.000	1.000
Quantity: Protein drink	0.942	- 0.059	1.000
Quantity: Carbohydrate drink	0.586	- 0.124	0.998
Quantity: Amino acid drink	0.443	0.144	0.969
Quantity: Another drink is taken	0.809	0.515	1.000
Temperature: very cold, <6°C	0.802	0.000	1.000
Temperature: cold and moderately cold, 6-19°C	0.334	0.255	0.471
Temperature: room temperature, 20-23°C	0.566	- 0.114	0.488
Temperature: warm and hot, >24°C	n.d.	- 0.559	0.899

n.d. - not detectable because all observed data are of the same value

The figures show the relevance of more than one parameter to be used in evaluating question validity. Cohen's *d* is more focused on the average, while the Pearson's correlation coefficient depicts a linear relationship between variables (Rebekić, Lončarić, Petrović & Marić, 2015).

Discussion

Questionnaires are standard tools in nutritional assessment, so it is important to that they are reliable. In this study, we designed and evaluated a questionnaire for the assessment of hydration practice among athletes (professional and recreational) before, during and after training.

In the development of this questionnaire, we considered the feasible causes of errors. They might include vagueness of questions, unfamiliarity with various hydration drinks, questionnaire length, types of predefined answers, etc. Therefore, we consulted sport scientists, coaches, nutritionists and athletes with an aim to minimize possible errors and ambiguity.

Table 3 Analysis of the degree of agreement for questions related to participants hydration during training

	Pearson coefficient	Cohen's *d* corrected	Chi square
Frequency: Water	- 0.091	- 0.256	1.000
Frequency: Electrolytes	0.586	0.168	1.000
Frequency: Fruit juice	0.540	- 0.168	1.000
Frequency: Classical cola beverages	1.000	0.000	1.000
Frequency: Sweetened coffee	n.d.	- 0.434	1.000
Frequency: Sweetened tea	n.d.	- 0.434	1.000
Frequency: Energy drink	0.847	0.322	1.000
Frequency: Protein drink	0.491	0.266	1.000
Frequency: Carbohydrate drink	1.000	0.000	1.000
Frequency: Amino acid drink	0.809	- 0.283	1.000
Frequency: Another drink is taken	n.d.	n.d.	1.000
Quantity: Water	0.688	- 0.205	1.000
Quantity: Electrolytes	n.d.	- 0.434	0.999
Quantity: Fruit juice	0.401	0.147	1.000
Quantity: Classical cola beverages	n.d.	n.d.	1.000
Quantity: Sweetened coffee	n.d.	n.d.	1.000
Quantity: Sweetened tea	n.d.	n.d.	1.000
Quantity: Energy drink	0.942	0.124	1.000
Quantity: Protein drink	0.942	0.124	1.000
Quantity: Carbohydrate drink	n.d.	0.434	1.000
Quantity: Amino acid drink	- 0.063	0.000	1.000
Quantity: Another drink is taken	n.d.	n.d.	1.000
Temperature: very cold, <6°C	0.882	- 0.243	1.000
Temperature: cold and moderately cold, 6-19°C	0.622	0.297	0.985
Temperature: room temperature, 20-23°C	0.551	0.209	0.537
Temperature: warm and hot, >24°C	n.d.	0.619	1.000

Table 4 Analysis of the degree of agreement for questions related to participants post-training hydration

	Pearson coefficient	Cohen's *d* corrected	Chi square
Frequency: Water	- 0.063	0.000	1.000
Frequency: Electrolytes	0.605	0.000	1.000
Frequency: Fruit juice	0.517	- 0.190	0.899
Frequency: Classical cola beverages	1.000	0.000	1.000
Frequency: Sweetened coffee	0.401	0.362	1.000
Frequency: Sweetened tea	0.401	0.362	1.000
Frequency: Energy drink	1.000	0.000	1.000
Frequency: Protein drink	0.648	0.000	0.988
Frequency: Carbohydrate drink	0.329	0.000	1.000
Frequency: Amino acid drink	0.727	- 0.190	1.000
Frequency: Another drink is taken	n.d.	n.d.	1.000
Quantity: Water	0.547	0.602	0.993
Quantity: Electrolytes	0.350	0.392	0.996
Quantity: Fruit juice	n.d.	0.841	0.984
Quantity: Classical cola beverages	1.000	0.000	1.000
Quantity: Sweetened coffee	0.889	- 0.362	1.000
Quantity: Sweetened tea	0.401	- 0.362	0.999
Quantity: Energy drink	0.401	- 0.147	0.998
Quantity: Protein drink	0.630	0.000	0.562
Quantity: Carbohydrate drink	- 0.063	- 0.194	0.364
Quantity: Amino acid drink	0.493	0.587	1.000
Quantity: Another drink is taken	n.d.	n.d.	1.000
When you drink it	0.731	0.000	1.000
Temperature: very cold, <6°C	0.586	0.124	1.000
Temperature: cold and moderately cold, 6-19°C	0.843	- 0.237	0.999
Temperature: room temperature, 20-23°C	0.529	0.110	0.519
Temperature: warm and hot, >24°C	- 0.063	0.000	1.000

Table 5 Analysis of the degree of agreement for questions related to general hydration habits of participants

	Pearson coefficient	Cohen's *d* corrected	Chi square
Reason for consuming Water	0.973	- 0.174	1.000
Reason for consuming Electrolytes	0.685	- 0.256	1.000
Reason for consuming Fruit juice	0.553	- 0.333	0.000
Reason for consuming Classical cola beverages	1.000	0.000	1.000
Reason for consuming Sweetened coffee	1.000	0.000	1.000
Reason for consuming Sweetened tea	0.685	0.256	0.999
Reason for consuming Energy drink	n.d.	0.265	1.000
Reason for consuming Protein drink	0.638	0.137	1.000
Reason for consuming Carbohydrate drink	0.685	0.161	1.000
Reason for consuming Amino acid drink	0.792	0.265	1.000
Reason for consuming Another drink is taken	n.d.	n.d.	1.000
Quantity, water, in summer	0.774	- 0.246	1.000
Quantity, electrolyte, in summer	0.889	0.000	1.000
Quantity, fruit juice, in summer	0.509	- 0.307	0.685
Quantity, classical cola beverages, in summer	0.688	- 0.440	0.996
Quantity, sweetened coffee, in summer	0.685	- 0.256	1.000
Quantity, sweet tea, in summer	1.000	0.000	1.000
Quantity, energy drinks, in summer	0.586	0.168	1.000
Quantity, protein drinks, in summer	0.685	0.446	1.000
Quantity, amino acids, in summer	0.889	0.362	1.000
Quantity, Another drink, in summer	n.d.	n.d.	1.000
Personal consumption rate	0.771	0.133	1.000

Thanks to pre-testing and data analyses, we determined questions that might be considered ambiguous or otherwise difficult to answer. In order to cover as many drinks that athletes use before, during and after training, who advices them on hydration, etc., many questions were designed as open-ended. We asked participants to report their average practice regarding frequency of certain type of fluids and amounts taken. The participants selected one of predefined answers regarding their health status, sports level, average number of training sessions and hours of training per week, intensity of training, time of drink intake before and after training, range of drinks temperature. Also, they could select drinks from predefined list or write another kind of drinks they usually use. It takes approximately 10 minutes to answer the questions.

Tables S1 to S5 show the level of agreement of answers between the first and second questionnaire sessions. Figures 2 and 3 show the comparisons, where the same trend (frequencies of answers) results with low values of Cohen's *d* and high Pearson's correlation. A Pearson's correlation coefficient greater than 0.65 is considered very strong, offering good reproducibility of answers to the same question (Rebekić et al., 2015). This is well above the cut-off value suggested by Munger et al. (0.45; 1992), and by Fernández-Ballart et al. (0.6; 2010). A questionnaire validation study assessed correlation coefficients in the range from 0.5 to 0.9 as relatively good (Klipstein-Grobusch et al., 1998). Wardle et al. (2001) suggested values over 0.8 indicate high reliability. A corrected Cohen's *d* parameter less than 0.2 shows no or small effect, while values from 0.2 to 0.5 show a medium effect in answering. We consider both ranges acceptable if the correlation coefficient was acceptable based on the number of participants and the cut-off values are set at 0.65 for the correlation coefficient and 0.5 for Cohen's *d*.

Some discrepancies were detected between the results of the two questionnaire sessions (Table 3). In the second round of questioning, students reported a lower preference towards "cold/quite cold drinks" and a higher preference for "room temperature drinks" during the pre-training period. This trend could be explained by that fact that the first questioning round was held in November 2017, when the air temperature was 15.26°C, while the second round took place in December 2017 when air temperatures were lower (12.9°C; AccuWeather, 2018). In general, warm food and drinks are preferred during colder periods (Oldewage-Theron, Dicke & Selepe, 2002).

During the second round of questioning, the participants reported lower preferences towards "room temperature drinks" during training (Table 4), which could not be explained by the lower air temperature.

At the same time, students reported a higher water intake after training (Table 5). The reason for this inconsistency cannot be explained by the change in intensity of trainings, which remained constant. However, some participants increased the number

of hours of training per week (Table S1), which might translate to more hours of training per day. Therefore, there is a probability that the sweating rate was higher, which resulted in a higher intake of water after the workout as the main means of rehydration.
There was a slightly change in the intake of carbohydrate solutions after training. Compare to the first round, in the second round of questioning, one more participant took 100 to 200 ml of carbohydrate solution and one less participant took 300 to 500 ml of this solution. Some participants increased the number of training sessions per week during the second round of questioning (data not shown), so it might be possible that this one participant increased the number of training sessions from one to two sessions per day, therefore ingesting more carbohydrate solution after training than before. It is well known that adequate carbohydrate intake soon after training contributes to the quick re-synthesis of glycogen in the body, which is crucial for performance and training quality, particularly if the athlete trains more than once per day (Burke, van Loon & Hawley, 2017).
It is recognised that power exercises followed by well-designed protein intake increase muscle mass (Aragon & Schoenfeld, 2013). Therefore, it might be possible that these students, with the aim of increasing muscle mass, participated in power training more often and supplemented their diet with amino acids, accordingly.
Finally, there are inconsistencies between the questionnaire sessions regarding the possible higher intake of cola and protein drinks during the summer. This could be explained by the fact that the study took place in winter and participants could not remember how their intake of these drinks changed during the summer.
Based on the results of statistical analyses, sport and nutrition scientists were consulted. Finally, several questions with poor reproducibility were modified and the final version of the questionnaire was defined (Table S5).

Conclusions

The results of this study show that the questionnaire has a high level of reproducibility and validity. It is reliable and could be regarded as a respectable and valuable tool in assessing hydration practice among athletes, regardless the gender and training level. By creating and validating the questionnaire of athlete hydration level, a new tool is provided to help athletes and the scientific/professional community gain valuable feedback on the hydration habits of athletes of various sporting activities in terms of their age and gender. Further testing of athlete hydration habits will provide important knowledge to all individuals involved in the training process.

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