

The issue of hydration and dehydration in orienteering disciplines when considering running in different types of terrain

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Abstract:

Background. Proper level of hydration during sports is essential factor that affects efficiency of an organism and therefore impacts the athlete's results. Orienteering is finding one's location and moving between checkpoints marked on a map. Due to its specificity, the discipline brings a lot of limitations for fluid intake and keeping the proper level of hydration. The aim of the study was to evaluate the hydration level and average degree of dehydration among the runners whilst performing the sport in correlation to the terrain they were moving around. **Methods.** The study was conducted in the period from December 2017 to February 2018. The test group consisted of 42 runners. The competitors made two 10km long running trials. The first test took place in a moderately flat terrain and the second trial took place in a moderately mountainous area. Before each of the running tests participants completed a short proprietary questionnaire on hydration aspects of the trial day. Before the running tests, each participant of the study was subjected to anthropometric measurements.

Results. Among 56% of runners, BMI values indicated abnormal body weight - overweight or obese. Before participating in the flat terrain trial, the subjects drank an average of 746.67ml. Then, during the run, their body weight decreased on average by 1.12% compared to the body weight before the test. Before participating in the trial in a mountain area, the average fluid consumption was 419.23ml. The average percentage weight loss during the mountain run in relation to the body weight before the test was 1.24%. The hydration level was determined by marking the number in the questionnaire that corresponded to the urine color produced before the running test. Most of the runners showed an incorrect hydration status before the run, both in the flat terrain (n = 24, 61.54% improperly watered) and in the mountain terrain (n = 23, 58.97% improperly watered).

Conclusions. Most of the runners ran with a water shortage or dehydrated, and therefore drank too little fluids. Moreover, the athletes dehydrated similarly in both trials, but slightly more in the mountain run; for competitors who were not properly hydrated prior to the run in the mountains, the percentage weight loss was higher than for competitors who were hydrated prior to that race. Measurements of body circumference and skin-fat folds may be helpful in testing athletes' dehydration.

Key Words: hydration, dehydration, orienteering, fluid intake, running

Introduction

Proper level of hydration during sports is truly essential factor that affects efficiency of an organism and therefore impacts the athlete's results. Water accounts for 55-65% of the body weight of adults and up to 70-75% of the body weight of children (Jarosz, 2020; Małecka et al., 2015; Joško-Ochojska et al., 2014; Kurzepa, 2014; Del Giudice et al., 2009; Niemiec et al., 2011; Idasiak-Piechocka, 2012; Załuska et al., 2012; Derkowska-Sitarz et al., 2008; Bień, 2014). Long-lasting insufficient water supply may lead to dehydration, thus disturbing homeostasis and consequently cause serious health problems. The effects of dehydration include in particular such disorders as: prolonged reaction time, decreased mental endurance, extended problem-solving time, increased subjective feeling of fatigue, decreased vigilance (Joško-Ochojska et al., 2014; Niemiec et al., 2011; Bień, 2014; Wiśniewska et al., 2014; Urdampilleta et al., 2014; Smith et al., 2012; Montain, 2008; Maughan et al., 2010; Ozkan et al., 2016; Friedline Weber et al., 2013; Kempton et al., 2011).

According to the International Orienteering Federation (IOF) - Orienteering is finding one's location and moving between checkpoints marked on a map. The name derives from the English verb "to orientate" meaning positioning, determining the location (Kulczycka, 2015; Iskra, 2006; Cegiełka et al., 2012; Colakoglu et al., 2014; Celestino et al., 2012; Hebert-Losier et al., 2014; Competition Rules for International Orienteering Federation, 2018). Orienteering is thus the activity of running combined with determining the position in the field. Due to its specificity, the discipline brings a lot of limitations for fluid intake and keeping the proper level of hydration. Therefore, the method of hydration before exercise, as well as fluid replenishment after its completion, becomes crucial. The **aim** of the study was to evaluate the hydration level and average degree of dehydration among the runners whilst performing the sport in correlation to the terrain they were moving around.

Material & methods

Participants. The study was conducted in the period from December 2017 to February 2018. The approval of the Bioethics Committee was not needed. The test group consisted of 42 runners aged between 19-64. The runners were selected arbitrarily, taking into account criteria such as age, running experience or the competitor's abilities. Ultimately, complete research material was collected from 39 people, including 7 women (17.95%) and 32 men (82.05%). The criterion for inclusion in the study was the giving appropriate consent to participate in the study, being at least 18 years of age on the day of the first running test, and practicing orienteering at least 1 year long. The exclusion criterion from the study was missing consent to participate in the research, less than 18 years of age or failure to participate in all stages of the research.

Procedure/Test protocol/Skill test trial/Measure/Instruments. The competitors made two 10km long **running trials**. The first test took place in a moderately flat terrain (hereinafter referred to as "flat terrain") with a height difference of about 110m, it constituted one loop. The second trial took place in a moderately mountainous area (hereinafter referred to as the "mountain area") with a height difference of about 400m, this run consisted of 3 repeated loops. The ratio of asphalt roads to forest paths in both trials, expressed as a percentage, was 60:40 in flat terrain and 56:44 in mountain area. The running tests took place in the afternoon, with similar weather conditions, taking into account the ambient temperature and sunlight. The average air temperature while the running tests were performed was $1^{\circ}\text{C} \pm 4^{\circ}\text{C}$.

Hydration Assessment Questionnaire before running tests. Before each of the running tests participants completed a short proprietary questionnaire on hydration aspects of the trial day. The survey included among others subjective assessment of urine color (Armstrong et al., 1994; Armstrong, 2000), amount of drunk fluids given in ml, type of consumed fluids, and subjective assessment of salt consumption. What is more, the survey was divided into two parts – one filled before the flat terrain test and the second part – filled before the mountain area test.

Urine colors 1 - 2 were considered as normal hydration, and colors 3 - 5 were water deficiencies of varying degrees (Armstrong et al., 1994).

Anthropometric measurements. Before the running tests, each participant of the study was subjected to anthropometric measurements consisting of:

- ☐ measuring body weight and height using a medical scale with a height measuring device (WPT 60/150 OW model),
- ☐ measurement of body circumference: chest, waistline, abdomen, hips, left and right arm, left and right thigh, left and right calf,
- ☐ measurement of skin and fat folds using a Harpenden foldmeter (M2 TOP, Käfer) with an accuracy of 0.1mm. Anatomical sites: a sub-scapular fold, a fold at the level of the left biceps muscle, a fold at the level of the left triceps muscle, and an abdominal fold.

The Body Mass Index (BMI) was determined on the basis of the formula: $\text{BMI} = (\text{body weight [kg]} / \text{height [m]})^2$ (Jarosz, 2020; Prajzner, 2008). The cut-off values for standardized BMI values were adopted in accordance with the WHO assumptions (<https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi>).

Data collection and analysis / Statistical analysis. Other factors influencing final hydration level were verified as well. Using the **current record method** and **individual consultations**, it was assessed how many times between the measurements the runner urinated, defecated or got rid of other body fluids (e.g. in case of vomiting). During the analysis, the reported amount was taken into account and based on the available sources it was assumed, that a single urination is 250ml and a single defecation is 150ml (Prajzner, 2008; Silva et al., 2010; Wronkowski et al., 2008). Collected data was considered a factor contributing to weight loss according to the mentioned values and appropriate numbers were subtracted from pre-run body weight. The amount of declared fluids and food consumed at that time was also taken into account. The comparative analysis of the results was performed on the basis of the values taking above information into consideration.

Statistical calculations were made using the MS Excel spreadsheet, MS Office 2013 and the IBM SPSS Statistics 23 program. The basic descriptive statistics were analyzed together with the Kolomogorov-Smirnov tests examining the normality of distribution for all quantitative main variables as well as for age, height and BMI. Correlation analysis with Spearman's rho coefficient, Mann-Whitney U test for independent samples, and analysis of covariance (ANCOVA) for repeated measurement were also made. The level of significance was considered to be $p < 0.05$. P scores ranging from 0.05 to 0.1 were considered statistically significant.

Results

Complete research material was collected from 39 people out of 42 respondents – 7 women (17.95%) and 32 men (82.05%). The age of the respondents ranged 19-64. The body weight and height of the respondents were interpreted using the BMI index and its normal ranges (Jarosz, 2020). Among 56% of runners, BMI values indicated abnormal body weight - overweight or obese, 44% of people taking part in the study had body weight complying with standard.

Table 1 shows the results of anthropometric measurements for both running tests.

Table 1. Results of anthropometric measurements in the flat terrain (FT) and mountain area (MA) trials

	X±S	Min.	Max.	K-S	p					
	FT	MA	FT	MA	FT	MA	FT	MA	FT	MA
Consumed fluids [ml]	746.67 ± 597.39	419.23 ± 243.7	120	100	3000	1500	0.2	0.19	<0.001	0.001
Difference in body mass value [kg]	0.89±0.3	1.0±0.36	0.38	0.1	1.8	1.55	0.16	0.13	0.019	0.107
% weighloss	1.12 ± 0.27	1.24 ± 0.38	0.7	0.17	1.84	1.91	0.13	0.09	0.074	0.2
Decrease in the thickness of the folds [mm]	3.28 ± 3.0	0.27 ± 0.74	-6.00	-1.3	13.00	2.3	0.16	0.15	0.2	0.032
Decrease in the body circumferences [cm]	0.08 ± 3.24	0.25 ± 0.42	-9.1	-0.6	5.3	1.1	0.09	0.11	0.066	0.2
Decrease in the L arm circumference [cm]	0.15 ± 0.6	0.02 ± 1.18	-1.0	-3.2	1.5	2.8	0.08	0.14	0.009	0.048
Decrease in the R arm circumference [cm]	0.11 ± 0.6	-0.16 ± 1.1	-1.4	-3.7	1.4	1.7	0.14	0.15	0.052	0.023
Decrease in the L thigh circumference [cm]	0.09 ± 1.55	0.15 ± 0.36	-3.0	-1.0	4.4	0.8	0.16	0.11	0.081	0.2
Decrease in the R thigh circumference [cm]	-0.03 ± 1.34	0.28 ± 0.58	-4.2	-1.0	3.0	2.1	0.14	0.1	0.169	0.2
Decrease in the L calf circumference [cm]	-0.1 ± 0.56	0.23 ± 1.47	-2.0	-3.4	0.6	3.0	0.13	0.07	0.2	0.2
Decrease in the R calf circumference [cm]	0.06 ± 0.53	-0.1 ± 1.35	-1.8	-4.8	1.2	2.1	0.12	0.12	<0.001	0.136
Decrease in the chest circumference [cm]	0.15 ± 1.31	0.16 ± 1.52	-3.5	-2.0	3.0	8.1	0.12	0.22	0.2	<0.001
Decrease in the waistline circumference [cm]	-0.5 ± 1.14	0.39 ± 1.03	-3.8	-1.4	1.5	4.2	0.22	0.14	0.043	0.056
Decrease in the abdomen circumference [cm]	-0.03 ± 1.56	1.49 ± 4.14	-3.5	-9.3	5.0	11.20	0.1	0.12	0.2	0.193
Decrease in the hips circumference [cm]	0.09 ± 1.23	1.97 ± 3.32	-3.4	-6.0	2.5	8.0	0.14	0.14	0.009	0.059

FT - flat terrain; MA - mountain area; X - average; S - standard deviation; Min and Max - the lowest and highest value of the distribution; K-S - the result of the Kolmogorov-Smirnov test; p - significance

Before participating in the flat terrain trial, the subjects drank an average of 746.67ml. Then, during the run, their body weight decreased on average by 1.12% compared to the body weight before the test. The sums of skin and fat folds, and body circumferences during the run decreased on average by 3.28mm in folds and 0.08cm in circumferences.

Before participating in the trial in a mountain area, the average fluid consumption was 419.23ml. The average percentage weight loss during the mountain run in relation to the body weight before the test was 1.24%. The decrease in the skin and fat folds, and in the body circumferences during the mountain trial were on average 0.27mm and 0.25cm.

Comparison of the amount of consumed water and the hydration lever before running in flat terrain and mountain area.

First, the amount of fluids consumed in both trials was compared. Before the run in the flat terrain, the subjects drank on average more fluids, the difference is statistically significant ($p < 0.001$).

The hydration level was determined by marking the number in the questionnaire that corresponded to the urine color produced before the running test. Most of the runners showed an incorrect hydration status before the run, both in the flat terrain ($n = 24$, 61.54% improperly watered) and in the mountain terrain ($n = 23$, 58.97% improperly watered).

The runners in the survey were also asked what fluids they drank before the run. Most of the competitors took water ($n = 21$, 53.84% before the flat test, and $n = 18$, 46.15% before the mountain test) and coffee or tea, including herbs ($n = 29$, 74.36% before the flat test, and $n = 24$, 61.54% before the mountain trial). Isotonic drinks containing electrolytes were consumed by the same number of respondents before trials ($n = 5$, 12.82% in both trials) as well as the same amount of people consumed milk, alone or as an addition to e.g. coffee ($n = 6$, 15.38 in both trials). Other drinks were consumed occasionally ($n = 11$, 28.21% before the flat test, and $n = 7$, 17.95% before the mountain test).

The last question in the pre-trial questionnaire was about salt consumption. Participants were asked if they had increased their sodium and salt intake recently and how. Only 3 of the respondents answered positively both before the flat terrain test and the mountain area test. Thus, these results were not analyzed.

Effect of urine color on fluid intake, percentage of body weight loss, and the total decline in body circumferences and folds.

For both running tests people whose urine color indicated proper hydration were compared to people whose urine color indicated dehydration in terms of the amount of fluids drunk, percentage of weight loss, and the total of the reduction in circumferences and body folds.

The analysis showed that during the mountain run people whose urine color indicated dehydration lost a greater percentage of their body weight, compared to those whose urine color indicated proper hydration ($p = 0.036$). The results for both trials are presented in Table 2.

Table 2. The effect of urine color on the amount of fluids consumed, the percentage of body weight loss, and the total decline in circumference and folds in both flat terrain (FT) and mountain (MA) trials

	Proper hydration $\bar{X} \pm S$	Dehydration $\bar{X} \pm S$	Z	p				
	FT	MA	FT	MA	FT	MA	FT	MA
Amount of consumed fluids [ml]	663.33 $\pm$ 535.68	903.12 $\pm$ 738.8	798.75 $\pm$ 638.44	637.83 $\pm$ 462.7	- 0.94	- 0.46	0.346	0.646
% body mass decrease	1.1 $\pm$ 0.3	1.04 $\pm$ 0.29	1.13 $\pm$ 0.25	1.17 $\pm$ 0.23	- 0.56	- 2.01	0.573	0.036
Total folds decrease [mm]	2.47 $\pm$ 3.58	2.94 $\pm$ 3.82	3.79 $\pm$ 5.29	3.52 $\pm$ 5.3	- 0.52	- 1.18	0.602	0.239
Total decline in circumference [cm]	-0.03 $\pm$ 3.98	-1.11 $\pm$ 3.19	0.15 $\pm$ 2.77	0.92 $\pm$ 3.07	- 0.35	-0.5	0.729	0.617

FT - flat terrain; MA - mountain area; $\bar{X}$ - average; S - standard deviation; Z - U Mann-Whitney test result; p - significance

Correlation between the amount of fluids consumed before the run to the percentage of weight loss, total of the reduction of both body circumferences, and skin and fat folds.

The amount of fluids drunk before the run was correlated with the percentage of weight loss, the total of the reduction in both body circumference, and skin and fat folds, separately for both running tests.

The analysis showed that the amount of fluids drunk before running in a flat terrain negatively correlated with the total of the reduction in body circumferences and folds. This means that the more fluids the subjects consumed before running in a flat terrain, the more they lost the circumference and body folds. However these relationships are moderate ($0.30 < r < 0.50$) and are described in Table 3.

Table 3. The influence of the amount of consumed fluids on the percentage of body weight loss and the total of the reduction in both body circumference and skin and fat folds

		%	Total decline in folds	Total decline in circumference
The amount of consumed fluids - FT	Spearman's rho	-0.03	-0.4	-0.33
	Relevance	0.852	0.011	0.042
The amount of consumed fluids - MA	Spearman's rho	0.18	-0.12	0.17
	Relevance	0.269	0.460	0.291

FT - flat terrain; MA - mountain area

The comparison of changes in body weight and body circumference between running in a moderately flat terrain and running in a mountainous area.

The difference in body weight, percentage of body weight loss, the total of decrease in skin and fat folds, and body circumferences as well as differences in individual body circumferences, considering a run in a moderately flat terrain and a run in a moderately mountainous terrain were compared.

The analysis showed no statistically significant distinction between the differences in individual circuits as well as in the total of the differences in folds and circuits. However considering the statistical trend only the

decrease in the circumference of the right thigh turned out to be significant – it was greater when running in the flat terrain. The results of the analysis are presented in Table 4.

Table 4. A summary of changes among the differences in body weight and circumference considering both running trials

		X±S	F	P	η²
Difference in body mass value [kg]	FT	0.89±0.3	0.54	0.468	0.01
	MA	1.0±0.36			
% weight loss	FT	1.12±0.27	1.35	0.253	0.04
	MA	1.24±0.38			
Decrease in the thickness of the folds [mm]	FT	3.28±4.7	0.0	0.985	0.00
	MA	1.97±3.32			
Decrease in the body circumferences [cm]	FT	0.08±3.24	0.16	0.696	0.00
	MA	1.49±4.14			
Decrease in the L arm circumference [cm]	FT	0.15±0.6	0.29	0.593	0.01
	MA	0.27±0.74			
Decrease in the P arm circumference [cm]	FT	0.11±0.6	2.47	0.125	0.06
	MA	0.25±0.42			
Decrease in the L thigh circumference [cm]	FT	0.09±1.55	1.18	0.284	0.03
	MA	0.02±1.18			
Decrease in the P thigh circumference [cm]	FT	-0.03±1.34	3.74	0.061	0.09
	MA	-0.16±1.1			
Decrease in the L calf circumference [cm]	FT	-0.1±0.56	2.84	0.1	0.07
	MA	0.15±0.36			
Decrease in the P calf circumference [cm]	FT	0.06±0.53	0.01	0.939	0.0
	MA	0.28±0.58			
Decrease in the chest circumference [cm]	FT	0.15±1.31	1.28	0.266	0.03
	MA	0.23±1.47			
Decrease in the waistline circumference [cm]	FT	-0.5±1.14	0.03	0.865	0.00
	MA	-0.1±1.35			
Decrease in the abdomen circumference [cm]	FT	-0.03±1.56	0.07	0.791	0.00
	MA	0.16±1.52			
Decrease in the hips circumference [cm]	FT	0.09±1.23	0.02	0.903	0.00
	MA	0.39±1.03			

FT - flat terrain; MA - mountain area; X - average; S - standard deviation; F - the result of the analysis of variance; p - significance; η² - effect size

Discussion

The obtained results show that most of the surveyed runners obtained higher BMI values than indicated by the norms. However, the average BMI was within the lower limits of overweight. It should also be remembered that among physically active people the BMI will not be reliable, because it only takes into account body weight and height, but does not take into account body composition and its proportions. Thus a person with a high muscle mass, and therefore a higher body weight, may obtain a BMI value indicating overweight or obesity, although this is not the case, what also noted by other authors (Wronkowski et al., 2008; Nastaj, 2012). However, it should be noted that in endurance disciplines, which include both running tests, the lower body weight of the competitors will allow them to exercise demanding less energy deposit. Moreover, in the case of orienteering runners, it can be assumed that a lower body weight and a slimmer body make it easier to navigate in the slushy and densely forested area (Kulczycka, 2015; Cegiełka et al., 2012; Hebert-Losier et al., 2014, Competition Rules for International Orienteering Federation, 2018, Kozłowski, 2007; Carlsohn et al., 2014; Czaja et al., 2008).

In the case of hydration before exercise, the results showed that the competitors consumed more than 746ml of fluids before the flat terrain race. Before the run in the mountainous area, they drank smaller amounts of fluids - on average less than 420ml. These results are surprising. It is known that physical exertion in more uneven terrain as well as the one with higher elevation increases its intensity and causes higher energy consumption, therefore it was assumed that runners consciously increased their fluid intake before the mountain trial (Carlsohn et al., 2014). However, the results did not confirm this. This may be related to the different dates of the running tests. One of the dates of the test in the flat terrain coincided with the sports competition – the Chrzanów New Year's Eve Run. During both running trials, the competitors were to cover the route at a similar pace and with a similar heart rate as recommended. Nevertheless, in the case of some competitors who took part in the first trial during the official start in competition mentioned above, they might have prepared for the race and paid more attention to proper hydration before it than in the case of the second trial, which they treated as a training. Moreover, the maximum fluid consumption before running in a moderately flat terrain was 3 liters. With such a high fluid consumption, there is a risk of hyperhydration of the body, which adversely affects its exercise capacity (Czaja, 2010).

Although the contestants were well hydrated before the trial started, the color of the urine in most of the cases indicated dehydration or water shortage. Therefore, it can be assumed that they started their running test with an insufficient amount of water in the body, which posed a risk of greater dehydration during the run. In addition, the fluids that runners reached for were not always the best choice to keep the body hydrated before running. Most of the competitors drank coffee and tea, which may have beneficial effect on the organism before exercise, but also acts dehydrating when consumed in excess. Moreover, herbal infusions which are also included in the tea group, may also have diuretic effect and are not the best choice before exercise (Michalak-Majewska, 2011). The competitors also reached for water, but an intense physical exercise lasting for about an hour, as in the case of a 10 km trial with additional height difference may require competitors to be better hydrated for example using fluids with the content of carbohydrates of up to 6-8%, as well as with the addition of electrolytes. These were used by only 13% of the respondents. It follows that the competitors may have used inadequate fluids and stay insufficiently hydrated which could have influenced the further stage of the research and the obtained results. Independent authors also noted inadequate fluid consumption by athletes of various disciplines and active people before exercise (Kozirok et al., 2013; Miśniakiewicz et al., 2016; Rivera-Brown et al., 2012).

Tested runners assessed their salt consumption before the run as corresponding to this on a daily basis. Only three of them claimed that they increased their salt intake, however, the products they used for this purpose (crisps, salty sticks) cannot be considered a good choice due to representing highly processed food, and containing high level of saturated fats as well as pro-inflammatory trans fats (Harvey et al., 2008; Goncalves et al., 2012). It should also be noted that the consumption of salt in Poland is too high in relation to the demand. Thus, in the case of runners, their daily dietary sodium content may be high enough and do not need to be increased (Sekula et al., 2010). Moreover, 5 people declared the consumption of isotonic drinks and electrolytes before the race, and 6 people declared the consumption of milk. Even if these people did not increase their sodium intake, those are beverages that contain more sodium and may sufficiently reduce the risk of sodium deficiency while running (Shirreffs, 2009). The runners could also believe that the distance of 10km covered in a time of up to 1 hour does not require them to increase their sodium intake, because the risk of hyponatraemia is much lower in shorter distances, and it concerns mainly athletes of long endurance disciplines - incl. marathoners, triathletes (Cegielka et al., 2012). The sodium content of the subjects' diet should be carefully examined in order to analyze its effect on water loss, including the reduction of body weight, as well as circumference and fat and skin folds.

Runners became dehydrated during each run, on average losing just over 1% of their body weight. Although the terrain they moved in did not show statistically significant differences in dehydration, in the case of mountain running both the percentage decrease in body weight and the decrease in body circumference was slightly higher than in the case of flat terrain running. However, one should take into account the numerous variables that could have had an impact on it. Among others, the average fluid consumption before the mountain run in relation to the flat run. Perhaps the greater dehydration in the mountainous terrain did not correlate to the slope of the terrain, but to the lower amount of fluids drunk before the run. In addition, running tests in winter conditions may entail the risk of improper clothing selection and overheating, and thus greater sweating. Perhaps some of the competitors in the mountain trial did not adjust their clothes to the weather conditions. It is also worth noting that the trials taking place at minus temperature may have resulted in less dehydration in subjects, due to less need to cool the body by sweating, than in the case of competitors who performed this test at temperature above zero centigrade, even if the temperature difference was only a few degrees (Sekula et al., 2010; Marszałek, 2009; Bogdan, 2009). Other authors noted average weight loss of 1.62% - 2.42% among competitors exercising in the winter period. However, attention should be paid to the duration of the exercise. They were footballers during training and half-marathon runners during the competition, whose exercise time exceeded 1 hour or its intensity was much greater (Sawka et al., 2007). In the case of hockey players in the study by Palmer and Spriet, they obtained similar percent weight loss in similar exercise time compared to runners in this study. What is more, juniors participated in the dehydration study in hockey players, and adults in the case of runners, which may be associated with a difference in the way and amount of sweating, and thus the dehydration of the body (Palmer et al., 2008).

It is also interesting that single body circumference measurements did not always indicate a reduction in particular circumference. In some cases even an average increase in circumference was recorded. This may be partly due to measurement errors, and above all from muscle swelling (including cell swelling) due to intense exercise, dehydration and loss of electrolytes with sweat (Bąkowski et al., 2008; Krzeszowiak et al., 2015).

The analysis of the correlation between the urine color indicating proper hydration and dehydration, and the loss of body weight, circumference, and folds in runners during exercise did not show many significant dependency. However, it was observed that competitors who in both trials competed dehydrated or with water shortages lost a greater percentage of body weight, recorded higher decreases in skin and fat folds, and body circumference. Nevertheless, only in the correlation between the color of urine (hydration rating) and the percentage decrease in body weight during mountain running these differences were statistically significant. The lack of significant differences may result, *inter alia*, from the size of the group. Perhaps research on a larger group would allow obtaining statistically significant results.

The analysis of the effect, which the amount of fluids consumed before the run had on the level of dehydration after the run, showed that despite the higher fluid consumption before the run, greater decreases in circumference and folds were observed. However, that was observed only among subjects running in moderately flat terrain.

Relating the obtained results to problems in orienteering, especially in foot orienteering, an important factor will be to start a training or competition in full, proper hydration, which the competitor can determine by the color of his urine. It is also worth paying special attention to replenishing fluids before the start, whenever possible, using drinks with the addition of carbohydrates and electrolytes, especially sodium. In case when the competitor can deliver his drink to the nutritional point, it is important that it is not clean water, nor is it hypertonic drink. And in the case when you have a choice of an isotonic drink and pure water at the "watering point", it is worth reaching for an isotonic drink.

Weighing the competitor before and after training performed in various terrains can help him determine what is his loss of water with sweat and develop an individual strategy considering the way of supplementing fluids after the end of different types of exercise – with various lengths, intensities, and in the uneven terrain in the amount of 100 - 150% decrease. In the case of orienteering, proper hydration and adequate salt intake may be important a few days before the start, especially in multi-stage competitions. Moreover, the importance of both of these factors increases in the final phase of the competition, where the runner is required to maintain concentration at the highest level. Therefore, there is a need to educate competitors of this discipline in the field of proper hydration and fluid replenishment considering the limitations of sports orientation.

Conclusions

The tested runners drank more fluids before the test in moderately flat terrain than before the test in mountainous area. Most of the runners ran with a water shortage or dehydrated, and therefore drank too little fluids; In order to hydrate the competitors most often chose clean water and infusions of coffee, tea and herbs. Moreover, the athletes dehydrated similarly in both trials, but slightly more in the mountain run; for competitors who were not properly hydrated prior to the run in the mountains, the percentage weight loss was higher than for competitors who were hydrated prior to that race. Along with the increase in fluid consumption before the flat terrain run, the total decrease in body circumference and folds after the run was also greater. The way of dehydrating runners, depending on the terrain they move, requires further research taking into account the consumption of fluids (including water contained in consumed food) as well as weather conditions, ambient temperature, subjects' clothing and diet, including sodium consumption before the run; Measurements of body circumference and skin-fat folds may be helpful in testing athletes' dehydration.

Conflicts of interest - The authors declare no conflict of interest.

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