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Research Article

Dehydration of Amateur Long-Distance Runners and Fluid Consumption -

Gabor Franko[1]*, Pongrac Acs[1], Sandor G. Vari[2] and Maria Figler[1]

[1]*Faculty of Health Sciences, University of Pecs, Hungary, Europe*

[2]*International Research and Innovation in Medicine Program Cedars - Sinai Medical Center, Los Angeles, CA, USA*

***Address for Correspondence:** Gabor Franko, Faculty of Health Sciences, University of Pecs, Hungary, Europe, E-mail: frankogabor@yahoo.com

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ABSTRACT

Introduction: The objective of our study was to establish to what extent isotonic drinks influence the results of athletes running in a half marathon (21 km).

Material and Methods: The study included 40 persons who ran in a marathon. According to their fitness level we divided them into 2 groups of 20 runners each: the trained group (athletes who run more than 30 km per week) and the non-trained group (athletes who run less than 30 km per week). We chose 10 persons from each group who consumed isotonic drinks and 10 who drank only water. During the race, the runners had to drink the same volume of liquid. In the first part of our study, we asked the participants to complete a questionnaire with 29 questions that included asking about their training level, whether they are knowledgeable about dehydration or if they had already experienced its symptoms. In the second part of the study, we took urine samples and performed body composition tests before and after the race. We measured changes in body weight, Total Body Water Percentage (TBW%) and urine specific weight. From the results, we tried to estimate the extent of dehydration during the race, also taking into consideration whether the runners consumed isotonic drinks or water.

Results: In both the trained and non-trained groups, 80% of the runners who drank isotonic drinks reported fewer symptoms of dehydration in comparison with those who drank only water during the race. The changes in the total body water percentage also verified that the athletes who consumed isotonic drinks were less dehydrated. They lost only 1% of their body water. The runners who drank only water all showed dehydration at different levels, the highest one being almost 5% of body water. The specific weight of urine showed similar changes. The specific weight of urine of those who drank only water increased significantly during the race ($P < 0.05$).

Keywords: Dehydration; Running; Semi-marathon; Isotonic drink; Water

INTRODUCTION

At the beginning of each New Year, people make resolutions to lose weight and live healthier. In light of this, more and more people, including in Hungary, choose to run a half marathon (21 km) or a full marathon (42 km). Evidence for this is the increased number of participants in the Spar Budapest Marathon and 2-day runners' festival held every October (Figure 1). This event is almost considered a tradition and will be held for the 33rd time in 2018.

Most novice runners have little knowledge about how to safely run distances of 21 or 42 kilometres. Their preparation and training regimen is not supervised by a doctor or specialist. Many beginning athletes give up running after one or two months due to complaints of muscle and joint problems.

Those who don't give up so easily, but are unaware of the potential risks of running, may expose themselves to serious injuries and medical conditions. Going for a weekend jog thought to be harmless, could have tragic consequences. There is a fatal outcome in a running competition almost every year. In the autumn 2015 half marathon in Budapest, a foreign runner felt faint six kilometres before the finish line. Despite receiving some brief medical help, he lost his life. Unfortunately, this Budapest competition was not the only one with a fatal outcome. Despite such and similar serious tragedies, no medical examination or permit is required to participate in running competitions in Hungary or in most foreign countries, up to this day.

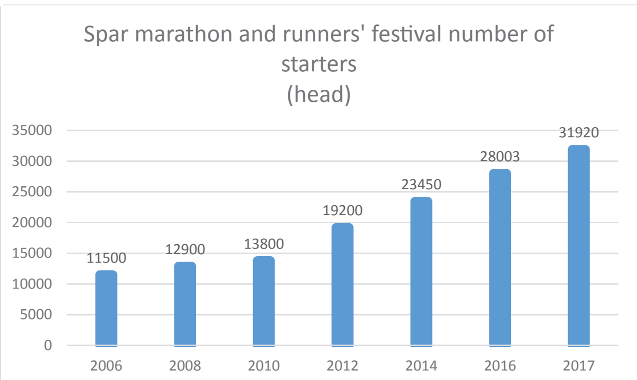

Figure 1: Number of participants in Spar Budapest Marathon Festival from 2006-2017 (Source: bsi.hu)

Most novice runners are aware that they need proper running shoes and a good training program, but very few know how much and what kind of fluids should be consumed while running in order to prevent dehydration of the body. Many runners are aware of the concept of dehydration and that the proper amount and quality of fluids are essential for the body's balanced functioning, but few know the consequences if they do not replenish lost fluid.

On the internet or in the literature there is different, conflicting advice regarding liquid consumption, which makes it very difficult to make the best choice. In the 1950s, for example, coaches advised the competitors to drink as few liquids as possible before and during the competition because it was thought to degrade their performance [1]. Fortunately, we meet less and less of this thinking and similar false information these days.

In light of such misleading information, it is not surprising that many people choose to rely on how they feel. However, when we feel thirsty, our body is already in a slightly dehydrated condition [2]. In this case, the fluid loss barely reaches 1% of body weight loss. But, if we still do not properly replace the lost fluid, and the body weight loss reaches 3-5%, the blood will start to get more dense. Higher density blood leads to decreased oxygen supply to the muscles, causing heavy performance loss and increased muscle regeneration time that leads to muscle cramps, and tachycardia.

In the United States, there are sporting events that exclude athletes from competition if liquid loss reaches 5% body weight loss, because the body is too dehydrated.

If the fluid loss increases further, it may lead to hypotonia, altered consciousness, and even coma. As a consequence of increased sweating the volume of circulating blood is reduced, so those who have some sort of heart and vascular disease are exposed to even greater risks if they undertake running [3].

The objective of our study was to establish to what extent isotonic drinks influence the results of athletes running in a half marathon (21 km).

MATERIALS AND METHODS

The study was carried out during the 2016 Várfürdő half marathon in Gyula, Hungary. The distance of the competition was 21,098 m. The temperature on the day of the competition was 75°F, with a relative humidity of 38 ± 5%.

Runners were excluded from the study if they:

(i) ever had any heart, muscle or kidney disease

(ii) we're taking any medication

(iii) we're not yet 18 years old or

(iv) Were amateur.

The participants in the study were randomly selected; each one voluntarily decided whether they wanted to participate. All participants were informed about the potential risks and possible inconveniences of the study. A signed consent statement was received from each study participant, in accordance with the guidelines of the Ethics Committee of the Faculty of Health Sciences, University of Pecs, Hungary.

For the measurements we divided the runners into two groups: a trained group (n = 20) and a non-trained group (n = 20). The trained group included athletes who run more than 30 km per week. The non-trained group included athletes who run less than 30 km per week. The ratio of genders was 50%-50%, with 10 women and 10 men in each group.

Each group had 10 runners who consumed only isotonic sports drinks (Gatorade cool blue; PepsiCo, Purchase, NY, USA) and 10 runners who consumed only water (NaturAqua non-carbonated; The Coca Cola Company, Atlanta, Georgia, USA) during the race. Both before and during the race, all runners had to consume 0.5 l of the liquid that was specified for them.

The sampling consisted of two parts. Before and after the race, the runners had to fill out a questionnaire, give urine samples and undergo a body composition test.

In the first part of the study, each participant completed a self-administered questionnaire of 29 questions that asked about the age of the runner, highest degree of education, physical activity, sporting habits, fitness levels, and fluid consumption habits while running (e.g., what liquids they consume, whether they consume alcoholic or caffeinated drinks during a race). The questionnaire also addressed their knowledge about dehydration and whether they have ever experienced symptoms of dehydration during running. The questionnaires were submitted anonymously.

In the next part of the study, urine samples were collected from the runners in sterile, closed-top plastic cups. Using test strips (CYBOW 11 urine rapid test; DFI Co.Ltd., 388-25, Gomo-ro Jillye-myeon, Gimhea-si, Gyeongsangnam-do 50875 Korea) the urine specific weight and pH were determined. The test strips were dipped in the urine and any excess was soaked up with sterile, fluid-absorbent paper. The test strips were then placed on a sterile tray and after 1 minute, the results were recorded. In addition, 5 ml of the urine samples were poured into sterile closable tubes, and then frozen at -80°C for later examinations.

Finally, all runners had to undergo a body composition test using a Tanita BC 420 Body Composition Analyzer (Tanita Corporation, Maenocho, Itabasi, Tokio, Japan). Body weight, Body Mass Index (BMI) and Total Body Water (TBW: Total Body Water is the total amount of fluid in the body expressed as a percentage of total weight) of the runners were determined. Those runners who passed the pre-race tests went on to compete in the race.

After the runners arrived at the finish line, the tests were performed again (urine test, body composition test) and the questionnaires were completed by answering questions about symptoms of dehydration during the race. Post-race measurements were performed within 3 minutes after the runners participating in the study reached the finish line. Study participants who completed the race were asked not to drink any other beverage until the tests were completed, so as not to affect the study results.

Weight loss was measured for all study participants. Since 90% of weight loss is caused by fluid loss, the dehydration level of the runners could be easily determined [4].

All statistical analyses were conducted using SPSS version 24 (IBM Corp., Armonk, USA) for Mac OS. Data are presented as the mean ± Standard Deviation (S.D.). The Kolmogorv-Smirnov test was used to ensure that all data had a normal distribution. All data were presented as means ± S.D. Paired t tests and Analysis of Variance (ANOVA) were used to evaluate within-participant differences between environmental conditions. The level of statistical significance was set at $p \leq 0.05$.

RESULTS

Table 1 shows the characteristics of the runners who participated in the study. There were no significant differences between the trained and non-trained groups in terms of age, body weight, height or body fat.

Responses to the questionnaires

The responses of the runners to the questionnaires were as follows. Of the 40 runners participating in this study, 62.5% (n = 25) have higher education qualifications and 38.5% (n = 15) have secondary school qualifications.

Table 1: Characteristics of the study participants.

	Trained	Non-trained
	n = 20	n = 20
Gender	10 women, 10 men	10 women 10 men
Age Women (years)	31 ± 4	32 ± 7
Age Men (years)	37 ± 8	36 ± 7
Body weight Women (kg)	54 ± 6.4	58 ± 7.7
Body weight Men (kg)	75 ± 11	78 ± 15
Height Women (cm)	156 ± 11	158 ± 15
Height Men (cm)	172 ± 11	175 ± 15
Body fat Women (%)	20 ± 5	25 ± 7
Body fat Men (%)	14 ± 3	18 ± 8

Before this race, 80% of the runners (n = 32 had previously participated in half marathon races and 5 runners had completed full marathons earlier. For 20% of the runners (n = 8) this race was their first challenge of this kind. These runners were in the "non-trained" group.

All 40 runners reported that they had experienced mild symptoms of dehydration earlier, during training or in competition. Further, 50% of these runners (n = 20) had already experienced more severe symptoms of dehydration during running.

From the questionnaires, it was also found that most of the respondents (80%) are aware of how much liquid should be consumed per day (along with average daily activities), but that only 40% of the respondents actually consume as much fluid as their bodies need. Of the 16 people who consume more than 2 litres of liquid per day, 14 of them have higher education degrees, clearly reflecting that those with more education are more knowledgeable about dehydration. The questionnaire responses also verified that those who run more than once a week have a higher daily intake of liquid.

The questionnaire responses after the competition showed that 80% of the runners who had consumed isotonic drinks (both in the "trained" and "non-trained" groups) experienced better performance, with only 30% of them (n = 6) experiencing mild symptoms of dehydration during competition. None of the runners reported more severe symptoms. In contrast, mild dehydration was experienced by all of the water consumers, with 40% of them (n = 8) indicating moderate symptoms of dehydration. One of the water consuming runners reported dizziness and altered consciousness, which indicates serious dehydration.

Changes in body weight of the runners

The average body weight of the runners who consumed water decreased significantly by 2.93% from pre-race (71.9 ± 10.8 kg) to post-race values (69.8 ± 10.7 kg) ($P < 0.05$). In runners who consumed isotonic drinks, the average body weight decreased significantly by 1.23% from pre-race (65.2 ± 6.1 kg) to post-race values (64.4 ± 6.5 kg) ($P <0.05$).

Changes in Total Body Water Percentage (TBW%) in women

In non-trained women, the mean TBW% in water consumers decreased from a pre-race value of 50.12 ± 2.48 to a post-race value of 48.94 ± 1.46, which represented a 2.35% decrease in the body fluid ratio (Table 2). In non-trained women who consumed isotonic drinks, the mean value of TBW% decreased from 48.62 ± 1.62 before the race to 47.74 ± 1.46 by the end of the race, which represented a 1.81% decrease in the body fluid ratio.

In trained women, the mean value of TBW% before the race for water-consuming runners was 50.46 ± 2.47 and decreased to a post-race value of 48.26 ± 2.06, which represented a 4.35% decrease (Table 2). The mean value of, pre-race TBW% for consumers of isotonic drinks was 48.74 ± 2.26 and decreased to 48.12 ± 2.58 by the end of the race, which represented a 1.27% decrease.

The mean of TBW% of those who drank waters during the semi-marathon decreased more significantly ($P < 0.05$).

Changes in Total Body Water Percentage (TBW%) in men

In non-trained men, the mean TBW% in water consumers decreased from a pre-race value of 55.98 ± 1.92 to a post-race value of 54.44 ± 2.34, which represented a 2.75% decrease in the body fluid ratio (Table 3). In non-trained men who consumed isotonic drinks, the mean value of TBW% decreased from 57.64 ± 4.16 before the race to 57.08 ± 3.92 by the end of the race, which represented a 0.97% decrease in the body fluid ratio.

In trained men, the mean value of TBW% before the race for water-consuming runners was 56.74 ± 5.56 and decreased to a post-race value of 55.92 ± 5.18, which represented a 1.44% decrease (Table 3). The mean value of pre-race TBW% for consumers of isotonic drinks was 57.0 ± 3.2 and decreased to 56.78 ± 3.12 by the end of the race, which represented a 0.38% decrease.

The mean of TBW% of those who drank waters during the semi-marathon decreased more significantly ($P<0.05$).

Changes in Total Body Water Percentage (TBW%) for water *vs* isotonic drink

In the trained runners, the mean of the changes in TBW% during the race was significantly higher for consumers of water compared to isotonic drinks in both women (2.2 vs 0.88, $P < 0.05$) and men (0.82 *vs* 0.22, $P < 0.05$). Similarly, in the non-trained runners, the mean of the changes in TBW% during the race was significantly higher for consumers of water compared to isotonic drinks in both women (1.18 *vs* 0.62, $P < 0.05$) and men (0.82 *vs* 0.56, $P < 0.05$). Thus, it is clear that the difference between the two measurements was higher for those who drank only water, indicating a higher rate of dehydration.

Changes in urine specific weight for water or isotonic drink

The pre-race urine specific weight was 1010 ± 5 g/ l for consumers of either water or isotonic drink (Figures 3, 4). It did not reach 1020 g/ l for any of the runners.

After the race, the runners who drank water had a significantly higher mean urine specific weight ($P < 0.05$) (Figure 3). This was the case in every group, with post-race vs pre-race mean values of 1025 *vs* 1010 g/l in both trained women and trained men, and 1030 *vs* 1010 g/l in both non-trained women and non-trained men.

Table 2:

	Mean Total Body Water (TBW) % in Women runners					
	Consumed only water during the race			Consumed only isotonic drink during the race		
Group	Pre-race	Post-race	% change	Pre-race	Post-race	% change
Non-trained women runners	50.12	48.94	2.35	48.62	47.74	1.81
Trained women runners	50.46	48.26	4.35	48.74	48.12	1.27

Table 3:

	Mean Total Body Water (TBW) % in Men runners					
	Consumed only water during the race			Consumed only isotonic drink during the race		
Group	Pre-race	Post-race	% change	Pre-race	Post-race	% change
Non-trained men runners	55.98	54.44	2.75	57.64	57.08	0.97
Trained men runners	56.74	55.92	1.44	57.00	56.78	0.38

Out of the water consumers, the results after the race were higher than the first measurement for each runner, reflecting the greater dehydration of the body. There were several water-consuming runners with urine specific weight of 1030 g/ l, which shows relative dehydration.

In the runners who consumed isotonic drinks, the mean urine specific weight remained the same (1010 g/ l) in both trained and non-trained men, and increased only slightly (to 1015 g/ l) in both trained and non-trained women (Figure 4).

At 1.5 hours after the competition when urine specific weight was re-measured for each runner, the results showed a normal level again (1010 ± 5 g/ l).

DISCUSSION AND CONCLUSIONS

The results clearly show that in the case of running for more than one hour, the content of the fluid used to replace the fluid lost during running is not negligible. It would be, however, very easy to make the wrong selection because we read in many places that water is the most suitable choice for fluid replacement. This is the case, as long as the intensity and duration of the activity do not exceed a certain level. On an average day, 300 to 800 ml of fluid is lost by sweating, which can be influenced by a number of factors (temperature, humidity, medicines, hot foods, number of sweat glands). In this situation, the proper volume of water is sufficient for fluid replacement. Water may also be sufficient to replace the lost liquid if the intensity of the sporting activity is low (temperature and humidity are not high) and the duration of activity does not exceed one hour.

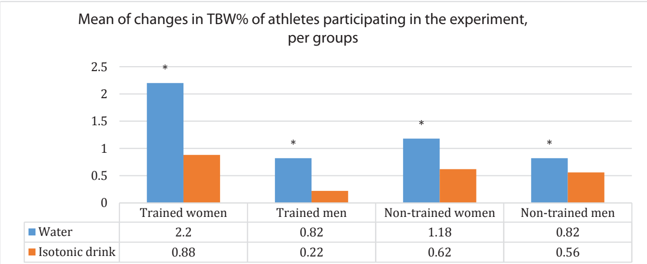

Figure 2: Mean of changes in TBW% of runners participating in the study. The groups were trained women (n = 10), trained men (n = 10), non-trained women (n = 10) and non-trained men (n = 10)
*P < 0.05 for all comparisons between water and isotonic drink in each group.

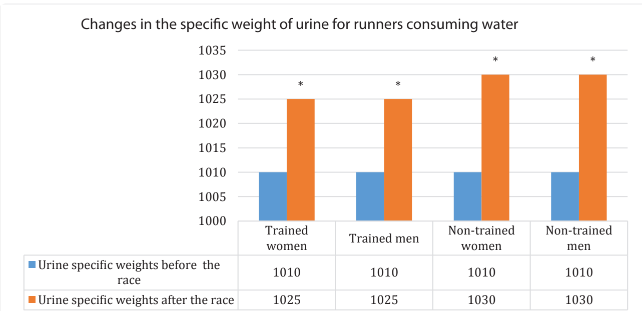

Figure 3: Mean values for the specific weight of urine in runners consuming water. The groups were trained women (n = 10), trained men (n = 10), non-trained women (n = 10) and non-trained men (n = 10)
*P < 0.05 for all comparisons between post-race and pre-race values in each group.

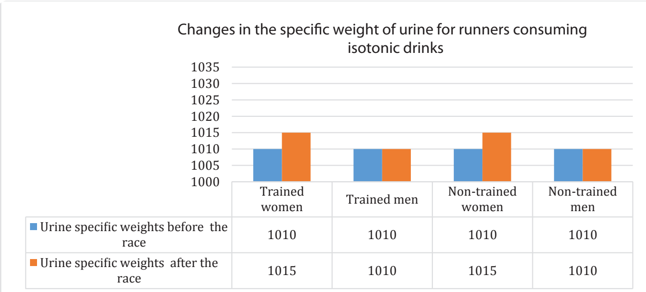

Figure 4: Mean values for the specific weight of urine in runners consuming isotonic drinks. The groups were trained women (n = 10), trained men (n = 10), non-trained women (n = 10) and non-trained men (n = 10).

However, if the intensity of movement is increased, the amount of fluid lost by sweating multiplies (1500-2500 ml), and increased amounts of minerals and trace elements are lost from the body that cannot be replaced with clean water. For proper muscle function, it is essential to replace sodium, calcium, potassium and magnesium. If the lost minerals are not replaced, the mineral depletion can lead to muscle fatigue, muscle spasms, or dysfunction of the body. Isotonic drinks have the same osmolality as the body's own fluids, and contain the same amount of electrolytes and carbohydrates. The isotonic drinks consumed in the study component had a sugar content of 34 g – sodium of 270 mg – potassium of 75 mg / 500 ml. Thus, such fluids are most effective to replenish lost fluids when the athletic activity is longer and includes more intense movements.

In conclusion, our study investigated the extent to which isotonic drinks influence the results of athletes running a half marathon. Our study findings provide information that can make long runs more effective, less strenuous, and more enjoyable for all novice, amateur or professional runners. Our goal is to prevent the injuries and medical conditions associated with dehydration.

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