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ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Nutritional intake during a 244 km multisport ultraendurance race

Paolo C. Colombani, Christof Mannhart[1], Caspar Wenk and Walter O. Frey[2]
Swiss Federal Institute of Technology, INW Nutrition Biology, CH-8092 Zurich, Switzerland
[1] Federal Office of Sports, Institute of Sports Sciences, CH-2532 Magglingen, Switzerland
[2] Swiss Sports Medical Center, Clinic Hirslanden, CH-8008 Zurich, Switzerland
E-mail: paolo.colombani@inw.agrl.ethz.ch

Abstract: Data about the nutrition during ultraendurance competitions are scarce, with the exceptions of few case reports. Because very long lasting sports events become more and more popular, we aimed to describe the nutritional intake during an extreme ultraendurance race carried out in Switzerland in 1998. The ultraendurance multisport race was 244 km long (48 km mountain biking, 122 km road cycling, 28 km roller blading, 3.5 km swimming, 42.5 km running; total altitude difference ± 4000 m). The 12 male finishers participating in the study completed the race in a median (and range) time of 18.6 (17.0-19.8) hours. Their energy intake during the race was 22.6 (12.4-33.6) MJ and corresponded to 44 % of their estimated energy expenditure. Carbohydrate, protein, net fluid, and net sodium intake amounted to 60 (36-90) $g \cdot h^{-1}$, 0.8 (0.1-2.4) $g \cdot kg^{-1}$ body mass, 560 (310-790) $mL \cdot h^{-1}$, and 13 (7-19) $mmol \cdot L^{-1}$ net fluid intake, respectively. In conclusion, the nutrition during the ultraendurance race was similar to the one recommended for shorter events like a marathon run and the focus was set upon a high carbohydrate intake.

Key words: Exercise, marathon, triathlon

Introduction

Ultraendurance events lasting ten or more hours have become very popular. A careful race preparation is in any case mandatory for all competitors and the successful accomplishment of such a race depends on many factors with nutrition certainly being one of them. It is now widely accepted that the nutrition during endurance events lasting up to a few hours like a marathon should mainly focus upon an adequate fluid and carbohydrate supply. But, with the exception of sodium, it is largely unknown if additional nutrients would be necessary for an optimal nutritional supply during ultraendurance races. Sodium has been suggested to be a critical nutrient during very prolonged races (Rehrer, 2001) and some cases of hyponatremia were reported after an ultraendurance race (Speedy *et al.*, 1999). It could be argued that some further nutrients might become critical (e.g. some amino acids), but this would be pure speculation according to current knowledge.

Because even descriptive studies about the nutrition during ultraendurance competitions are scarce and most of the published reports were case studies (Clark *et al.*, 1992; Gabel *et al.*, 1995; Eden and Abernethy, 1994; Rontoyannis *et al.*, 1989; Lindeman, 1991; Hill and Davies, 2001), we aimed to describe the nutrition during an extreme ultraendurance race on a large scale. The ultraendurance race which took place in Switzerland in 1998 was the Gigathlon. It consisted to cross the country from south to north and to cover 244 km with an altitude difference of ± 4000 m by mountain biking, road cycling, roller blading, swimming, and running. The goal of the study was therefore to track the nutritional intake on the race day of the greatest possible number of competitors.

Materials and Methods

Subjects: Fifty-three of the 216 registrants answered the advertisement of the study, which was published with the application form. They were informed about the purpose and the procedure of the study and, in order to familiarize with the study design, they received a copy of the nutrition log books to be used during the study a few weeks before the race. Any question related to the study was answered by phone and a final and compulsory information meeting was held just after the check-in to the race on the day before the race. Twenty-seven competitors either did not start the race, did not appear at the information meeting, or preferred to withdraw from the study. The study was therefore carried out with the 26 remaining competitors. Fourteen competitors did not finish the race, so that only results of the 12 finisher (=subjects) are presented. The study drop out rate corresponded to the overall drop out rate of the race (114 finisher out of 216 starter). The median (range) age of the 12 male subjects was 34 (20-48) y and they weighed 74 (63-84) kg.

The exercise volume of the subjects was assessed for a common week (CW) and for an "intensive" week (IW), such as during the preparation for a competition. The mean and range exercise volume in kilometers per week was for mountain biking CW=25 (0-60), IW=45 (25-130); for road cycling CW=113 (40-300), IW=313 (150-750); for roller blading CW=10 (0-40), IW=30 (20-60); for swimming CW=2 (0-8), IW=5 (3-20); and for running CW=25 (15-55), IW=60 (35-120).

Ultraendurance race: The 244 km long race "Swiss Gigathlon 1998" crossed Switzerland from south to north and consisted of 48 km mountain biking, 122 km road cycling, 28 km roller blading, 3.5 km swimming, and 42.5 km running with a total altitude difference of ± 4000 m. The start of the race was set at 6 am and the race had to be completed within 20 hours. The weather conditions varied along the route, but they were in general cool and humid. Each athlete had one or more personal assistant(s) and coaching was allowed in the transition areas after each stage of the race.

Nutritional intake: Because planning the race nutrition was part of the preparation of a subject, the food items to be consumed during the race were known in advance. All food items that a subject planned to consume were therefore listed in an individualized log book used for the nutrition recall. The recall was logged immediately after completing each stage in the transition area by the personal assistants of the subject (the assistants were previously instructed in keeping note of the log book). The nutrition of the last stage was logged either by the assistants of a subject or by a member of the research staff.

The nutrition recall of the just completed stage was usually made by subtraction of the amount of a given food item carried by the subject at the end of the stage with the amount of items the subject had taken with him at the beginning of the stage. During the race it was moreover allowed to pick up food from the official aid stations of the organizing committee. Because the number of the stations and the food items provided were known to the subject, picking up food was part of the planned nutrition schedule of a subject. The recall of the food picked up during a

Table 1: Median and range race time and energy balance (n = 12) for each stage of the 244 km multisport ultraendurance race Gigathlon. The altitude difference of the race as ±4000 m and it had to be completed within 20 hours

	Mountain biking 48 km	Road cycling 122 km	Roller blading 28 km	Swimming 3.5 km	Running 42.5 km	Total 244 km
Race time h	4.0 (3.5-4.3)	5.2 (4.9-6.5)	1.8 (1.4-2.5)	1.7 (1.4-2.0)	5.7 (4.4-6.9)	18.6(17.0-19.8)
Energy expenditure[1] MJ	11.6 (9.0-13.3)	19.5 (16.1-22.0)	4.3 (3.6-4.6)	3.7 (3.3-4.3)	13.3 (11.2-15.1)	51.7(43.7-58.9)
Energy intake MJ	4.4 (1.8-10.6)	8.0 (3.0-11.6)	0.3 (0.0-6.7)	2.6 (0.5-5.5)	6.2 (1.9-12.1)	22.6(12.8-33.6)
Energy balance	-7.2	-11.5	-4.0	-1.1	-7.1	-28.1

[1] The energy expenditure during the race was estimated using energy expenditure tables (Williams, 1997; Anonymous, 1999) and race times for each stage and athlete individually. To consider the altitude difference of the race, the energy amount to lift a defined mass to a defined height (E = body mass x gravity force x altitude difference) was added to the energy expenditure estimation. The mass of the mountain bike and the racing bike were included in the energy expenditure calculations.

Table 2: Median and range relative nutrient intake (n = 12) for each stage of the 244 km multisport ultraendurance race Gigathlon. The altitude difference of the race as ±4000 m and it had to be completed within 20 hours

	Mountain biking 48 km	Road cycling 122 km	Roller blading 28 km	Swimming 3.5 km	Running 42.5 km	Total 244 km
Energy $kJ \cdot min^{-1}$	17.6 (7.5-41)	24.0 (9.5-37.0)	2.8 (0.0-60.0)	25.0 (6.1-53.0)	18.5 (5.6-40.6)	19.3 (11.5-29.4)
Carbohydrate $g \cdot min^{-1}$	0.9 (0.4-2.2)	1.1 (0.5-0.8)	0.1 (0.0-3.0)	1.2 (0.3-2.7)	0.9 (0.3-2.2)	1.0 (0.6-1.5)
Water $L \cdot h^{-1}$	0.57 (0.30-1)	0.61 (0.09-0.81)	0.12 (0.0-0.49)	0.64 (0.19-1.62)	0.50 (0.16-1.35)	0.56 (0.31-0.79)
Sodium from drinks[1] $mmol \cdot L^{-1}$	5 (1-14)	5 (2-12)	60 (0-90)	5 (0-30)	4 (0-10)	9 (5-13)
Total sodium [1,2] $mmol \cdot L^{-1}$	6 (3-17)	12 (5-41)	79 (0-90)	7 (3-40)	7 (4-34)	13 (7-19)

[1] Data of only six subjects were included in the sodium results, because the sodium content of part of the food items ingested by the remainder six athletes could not be uncovered.
[2] Total sodium intake was set in relation to total fluid intake for better comparability with sodium intake from drinks.

stage was usually made by recalling how many deviations from the scheduled pick ups were done.
Food items were evaluated for water, energy, carbohydrate, protein, fat, and sodium content using in descending order nutritional information supplied on the food labels, nutritional information provided on request by the manufacturer of the product, or by use of the nutrition analysis software EBIS (version 1.1, University Hohenheim, Stuttgart, Germany), which is based on the official Federal German Food Key. Because the sodium content of some food items could not be uncovered for six subjects, the sodium results were presented for the remainder six athletes.

Body mass and race energy expenditure: Body mass was recorded after the breakfast before the start and after completing the race on a scale with a 50 g precision. The energy expenditure during the race was estimated using energy expenditure tables (Williams, 1997; Anonymous, 1999) and individual race times for each stage. To consider the altitude difference of the race, the energy amount to lift a defined mass to a defined height (E = body mass x gravity force x altitude difference) was added to the energy expenditure estimation. The mass of the mountain bike and the racing bike were included in the calculation of the energy expenditure of the two bike stages.

Statistics: Data were presented as median and range in text and tables.

Results

The race was completed in a median time of about 18 ½ hours (Table 1) and the body mass of the subjects was reduced by 5.5 % at the end of the race (73.6 (63.1-83.8) kg before the race vs. 70.3 (59.3-79.8) kg after the race).
The energy balance was negative for each individual stage resulting in an overall negative balance of 28.1 MJ (Table 1). The energy intake corresponded to about 45 % of the energy expenditure. The median relative nutrient intake was 15.0 (9.9-24.0) $g \cdot kg^{-1}$ body mass for carbohydrates, 0.8 (0.1-2.4) $g \cdot kg^{-1}$ body mass for protein, and 0.4 (0.1-1.5) $g \cdot kg^{-1}$ body mass for fat resulting in a median energy provision of 90 (65-99) % from carbohydrates, 5 (1-15) % from protein, and 7 (1-20) % from fat. The median fluid intake was 560 $mL \cdot h^{-1}$ and the overall sodium intake (n = 6) of 13 mmol per liter net water intake corresponded to an intake of 0.17 (0.06-0.31) $g \cdot h^{-1}$ (Table 2).

Discussion

Energy balance: The energy intake during the 18 ½ hours of the Gigathlon was 23 MJ and resulted in a negative energy balance of 28 MJ. A large part of the energy provision on the race day derived therefore from endogenous stores. Interestingly, well-adjusted energy balances were more often reported during ultraendurance events lasting several days compared to one-day events, irrespective of the magnitude of the energy expenditure (Gabel *et al.*, 1995; Saris *et al.*, 1989; Rontoyannis *et al.*, 1989).

Carbohydrate intake: The carbohydrate intake of 60 $g \cdot h^{-1}$ during the race was probably sufficient to sustain a high carbohydrate oxidation rate, because maximal oxidation rates occur at exogenous intakes of 1.0 to 1.5 $g \cdot min^{-1}$ (Jeukendrup and Jentjens, 2000). This is supported by a recent finding, that providing 60 g of carbohydrates per hour during a six hours ride at 55 % VO_2max indeed sustained a high oxidation rate of nearly 50 $g \cdot h^{-1}$ in the later stages of the exercise bout (Rauch *et al.*, 1998).
A main benefit of an adequately high carbohydrate intake during an exercise bout is probably the prevention of a rapid hepatic glycogen depletion and the maintenance of a stable blood glucose concentration, which would reduce the need to increase gluconeogenesis. Support for this notion comes from a study in which already a moderate carbohydrate ingestion of 35 $g \cdot h^{-1}$ during an exercise bout at 50 % VO_2max reduced the hepatic glucose production by about 60 % (Jeukendrup *et al.*, 1999). An ingestion of 175 $g \cdot h^{-1}$ even completely blocked the hepatic glucose production.
The carbohydrate intake of about 60 $g \cdot h^{-1}$ corresponded to an intake of 15 $g \cdot kg^{-1}$ body mass, which is more than the amount recommended for extremely prolonged and intense exercise (10-12 $g \cdot kg^{-1}$ body mass (Hawley and Burke, 1998)).

Protein intake: The relative protein intake was low during the race and contributed to about five energy percent to the energy intake. Quantitative amino acid oxidation is only marginal during endurance exercise (Hargreaves and Snow, 2001) but it might become qualitatively important (Gibala, 2001) in particular with depleted glycogen stores. A major fate of protein degraded in condition of liver glycogen depletion is to provide gluconeogenetic precursors. This raises the question if the endogenous protein degradation during exercise would be attenuated by exogenously increasing the amount of circulating amino acids (similar to a liver glycogen sparing by carbohydrate intake), but according to our knowledge, for prolonged exercise situations this issue was not addressed up to now.

Fluid and sodium intake: Ninety-six percent of the total fluid intake of 560 $mL \cdot h^{-1}$ derived from drinks and only 4 % from solid food. The fluid intake was within the range reported in literature (550 $mL \cdot h^{-1}$ during a 100 km run (Fallon *et al.*, 1998) and 800-900 $mL \cdot h^{-1}$ during a 960 km run (Rontoyannis *et al.*, 1989)) and within the range of general recommendations for fluid replacement during exercise (450 and 1200 $mL \cdot h^{-1}$ (Horswill, 1998)).

Fluid replacement prescriptions should by now probably be the best known nutritional recommendation for athletes, because dehydration is a major performance deteriorating aspect. However, the fluid intake of four athletes in the present study was lower than 450 $mL \cdot h^{-1}$, and an insufficient fluid intake of only 250 $mL \cdot h^{-1}$ was even reported for competing professional cyclists (GarciaRoves *et al.*, 1998). It seems therefore that not all athletes are aware of the importance of an adequate fluid intake.

Excessive water intake, on the other hand, might also be deleterious and lead to hyponatremia. For example, 18 % of the finisher of the 1997 New Zealand ironman triathlon were reported to be hyponatremic (Speedy *et al.*, 1999). Although the reasons for its occurrence are not conclusively uncovered, hyponatremia is discussed to develop as a consequence of salt depletion from massive sweat loss associated with net dehydration, excessive water intake, and large fluid shifts (Vrijens and Rehrer, 1999). To prevent hyponatremia during ultraendurance races, it was even recommended to ingest 1 g sodium per hour, which corresponds to 32 to 46 $mmol \cdot L^{-1}$ with a fluid intake of 500 to 700 $mL \cdot h^{-1}$ (Douglas and Hiller, 1989). For comparison, sports drinks commonly have a sodium content of only 10 to 25 $mmol \cdot L^{-1}$ (Maughan, 1998). The median sodium content of the ingested drinks in the present study was 9 $mmol \cdot L^{-1}$ with a fluid intake of 560 $mL \cdot h^{-1}$. And even if the sodium intake derived from solid food was taken into account, a hypothetical content of only 13 mmol per liter net fluid intake would result. It would have been of interest to assess the blood sodium content to verify if the low sodium intake had caused hyponatremia, but because of logistical problems it was not possible to draw blood samples immediately before and after the race.

Concluding remarks: Assessing the nutrition during a competition is a difficult task because several factors could affect its accuracy. However, because of the following reasons, we believe that the accuracy in the present study was high. First of all, the race was an extraordinary event and carefully planned by the subjects. Second, all food items available during the race were known in advance which allowed for an individual preparation of the log book for the nutrition recall. Third, the recall was simplified because the subjects and their assistants had scheduled the nutrition so that any deviation from the planned schedule could be remembered more easily.

To summarize, the nutrition during the extreme ultraendurance race Gigathlon was similar to the one recommended for exercise events lasting only a few hours, and the focus was set primarily upon a high carbohydrate intake, which reached an amount allowing for a high carbohydrate oxidation rate. The sodium intake was low, reflecting on the one hand the low sodium content of the ingested drinks and on the other hand the rather low fluid intake.

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