Case report

Nutrition planning and hydration control during a six-stage Pirineos FIT Endurance trail-running race. A case report

Eraci Drehmer[1], Mª Ángeles Navarro[1], Sandra Carrera[2], Roberto Herrera[1], Carlos Sanchis[1], Mari Luz Moreno[1]

[1]Catholic University of Valencia, Faculty of Physical Activity and Sport Sciences Email: eracil.drehmer@ucv.es; [2]Catholic University of Valencia, Human Nutrition & Dietetics - Faculty of Medicine & Odontology

Summary. Ultra-endurance competitions are highly demanding sport events for athletes and require a carefully controlled nutrition, hydration and supplementation before, during and after the physical effort. Scientific research has shown a positive relationship between dietetic (caloric and macronutrient ingestion) recommendations and sport performance. This study describes the nutritional and hydration planning applied to an athlete competing at the Pirineos FIT (a semi-self-sufficient trail-running multi-stage event). Diary caloric ingestion was around 4000 Kcal, 550 Kcal were consumed during the race. In general, the athlete maintained the minimal recommendable levels of hydration (2.5% Body Weight Loss) and Borg's Scale of Exertion (RPE) was used to report subjective perception of fatigue after each stage. Hematological and biochemical parameters showed a normal response to endurance physical exercise. Therefore, the nutrition and hydration planning were successfully applied.

Keywords*:* trail-running, hydration, nutrition planning, Spanish Pyrenees

Introduction

"Pirineos Fit" is an international event in Jaca (Spain), a 234 km and 15.075 m elevation gain six-day stage trail-running race. In this competition, participants have to complete the stages (34-41 km) in semi-self-sufficient conditions (athletes carry food and equipment, only providing two points of liquid provisioning during each stage). Participation in long lasting single and multi-stage endurance events has been growing over the last decades (1-3) despite their high physiological (4), nutritional (5) and psychological (6) demands. Although athlete physiological and hydric response has been recently described in single-stage ultra-endurance trail running races (4,7), little is known about its biochemical response and nutrition control during trail-running multi-stage races, with only a few studies assessing hydration status and heart rate in short (three days) races (8,9).

Macronutrient and fluid intake during endurance events should be a major concern for athletes, coaches and nutritionists to ensure both performance and health during competition. Correct nutrition reduces energy depletion, physiological stress and gastrointestinal problems, increases performance and accelerates recovery (10,11); while adequate hydration avoids hyponatremia, hyperthermia and central nervous system dysfunction (12,13) that leads to low performance and health damage.

The aim of this study is to describe a successful case of nutritional and hydration planning of a six-stage trail-running race in the Spanish Pyrenees.

Interventions and methods

Athlete

Our participant was a highly trained (65.3 ml·kg·min VO_2max) and fit (Weight = 66.15 kg; BMI = 22.49 kg/m^2; Fat Mass = 11.05 %; Free Fat Mass = 42.28 %; ∑ 8 Skinfolds[1] = 55.4 mm; Basal metabolism[2] = 1664 Kcal) 29-years-old male with significant training and racing history in trail-running: 14 years specific training, more than 300 endurance flat running events, various podiums in short trail races (2nd place at "Liga Serranía" 2017, Spain), and participations in ultra-trail events of 200-330 km in semi-self-sufficient conditions. Informed consent approved by Catholic University of Valencia was obtained.

Race

"Pirineos FIT" is a six-day stage race, from Panticosa to Jaca where the athletes (> 18 y/o) compete covering the distance of each stage. Officially[3], stages range from 34 to 41 km with 1460-3565 m of positive accumulated ascension (m+). Organization ensures correct marking of the stages but is the athlete the responsible for localization and orientation. Event requires athletes carry all food and equipment, only providing two points of liquid provisioning during each stage.

Training

Training preparation for "Pirineos Fit" started August'16 and implied 295 training sessions, 405 h of running, 105625 m+ and 3429.1 km. During this period, maximum training volume ranged between 15h 29' and 21h 10' (including a 110 km ultra-endurance event in September'16); while minimum training volume was established in April with 5h 47' of training. Last training was programmed for the last four months before the race, with two months of general preparation (March-April) and two months of specific ultra-endurance training (May-June). The best performance results accomplished by the athlete during the preparation process where at "Maratón de Alcublas" (21.9 km; 1h 48'; 705 m+; 2nd overall), "Tail Vielha-Molieres" (40 km; 4000 m+; 7h 17'; 14th overall) and "UTES" (106 km; 6200 m+; 14h 58'; 1st overall).

Using Skinner & McLellan's triphasic model (14), during preparation process, 27.9% of the time was spent in Phase I, 54.2% in Phase II and 18.4% in Phase III.

Nutrition planning and record

Key recommendations for the competition were given to the athlete, aiming to reduce dehydration, hyponatremia and to minimize body weight loss (BWL) to 1-3 %, considered a minimal level of dehydration (15). Main recommendations were to control hydric and electrolytic reposition ingesting 400-600 mL/h of fluid, 460-1150 mg/L of Na^+ and ensure periodic ingestion of carbohydrates (30-60 g/h) (15-17). During "Pirineos FIT", the method used for dietary assessment prior (breakfast), during (intra-competition) and after (post-race, lunch, afternoon, snacks and dinner) each stage was registered based on Food Record as described on Larson-Meyer et al. (18). This record includes food, supplement and fluid intake. Nutrients register was calibrated with the software "*Programa Alimentación y Salud*" v.2 (Granada University, Spain). Additionally, subjective effort perception and feeling, along with the heart rate (HR) were reported by the athlete.

24 hours before competition the athlete ingested 4032 kcal/16854 kJ, 598 g of carbohydrates (9 g/kg), 167 g of proteins (2.52 g/kg) and 124 g of lipids. BWL was registered by the athlete, measuring body weight immediately before and after each stage using a portable scale (*Model 876 Seca,* United Kingdom).

Blood samples were taken before and after the event. 28 biochemical markers were assessed by Megalab S.A. (*Madrid, Spain*): total, HDL and LDL cholesterol, triglycerides, transaminases (GOT-AST, GPT-ALT), iron, ferritin, urea, ureic nitrogen (BUN), creatin kinase, isoenzyme MB, Na^+, K^+, Cl^-, Ca^{++}, thyroxine, thyroid stimulating hormone, testosterone, cortisol, glucose, vitamin B12, reactive protein C, erythrocytes, hemoglobin, hematocrit, mean corpuscular hemoglobin and lymphocytes.

1 Skinfolds measured following International Society for the Advancement of Kinanthropometry (ISAK) methodology: tricipital, subscapular, chest, axillar, abdominal, thigh, suprailiac, rear thigh.
2 Basal metabolism was calculated based on Harris Benedict formula: 66.5 + (13.75 x weight (kg)) + (5 x height (cm)) – (6.78 x age (years old)).
3 Distance and positive accumulated ascension were modified day-today by the race organization due to necessary track modifications.

Statistical analysis

Measurement data are presented as mean ± SD. The software used to analyze the data was Microsoft Excel.

Observations and outcomes

Race-day intakes

Athlete's nutrients and supplements intake, together with its nutritional value, during the six stages are shown in Table 1. Breakfast (three hours before competition) was always the same (Table 2). Immediately before each stage (within the last 20-30 min) one antioxidant capsule and two mineral capsules were ingested, providing 50 mg of coenzyme Q, 40 mg of vitamin C, 20 mg of phosphatidylserine and 5 mg of NADH in order to improve physical performance and reduce oxidative stress associated to exercise (19, 20) and 128 mg of Na^+, 180 mg K^+ and 151 Mg^{++} in order to rebalance the acidified medium and keep cellular homeostasis respectively. During the first two stages, a 100 kcal reposition beverage (protein: 6 g; carbohydrates: 21 g; Na^+: 240 mg) diluted in 500 mL of water was added.

Table 2 shows nutrient and supplement intake during each day of competition (before, during and after each stage). Differences between stages in nutrient, supplements intake and fluid ingestion (water and reposition beverage) were due to specific characteristics of the stage (Table 3). Caffeine ingestion in the first stage was due to the ingestion of a sport gel containing 22.5 mg of anhydride caffeine and 31.5 g of carbohydrates. The reposition beverage provided a mix of different high glycemic index carbohydrates (glucose, maltodextrin, sucrose: 21 g/30 g), Na^+ (240 mg/30 g), Mg^{++} (151 mg/30 g) and branched chain amino acids (BCAAs) (6 g/30 g). Complementarily, aiming to optimize sodium intake, salt capsules were used which provided 430 mg of Na^+, 5.04 mg of Ca^{++} and 10.09 mg Mg^{++}.

During stage four, nutrient and supplement intake was markedly lower than in the others due to an orientation mistake (see table 2) that focused the athlete on finding the correct path to the finish line.

Table 1. Athlete nutritional intake during each stage

Stage	Intake	Energy (kcal/kJ)	CH (g)	P (g)	F (g)	Na^+ (mg)	Caf (mg)	Antioxidants (mg)
One	45 g reposition beverage in 700 ml of water, 1x sport bar, 150g banana, 5x salt capsule, 1x sport gel, 1.5 L water, 1x antioxidant capsule	717/2996	165.98	12.90	1.07	1442	22.5	50mg Coenzyme Q, 40mg vitamin C, 200mg phosphatidylserine, 5mg NADH
Two	30 g reposition beverage in 500 ml of water, 2x sport bar, 4x salt capsule, 1.5 L water, 1x antioxidant capsule	390/1630	87.83	7.15	0.27	1109	-	50mg Coenzyme Q, 40mg vitamin C, 200mg phosphatidylserine, 5mg NADH
Three	60g reposition beverage in 1000 ml of water, 2x sport bar, 150 g banana, 20 g raisins, 8x salt capsule, 4 L water, 1x antioxidant capsule	689/2082	154.03	15.50	0.90	2216	-	50mg Coenzyme Q, 40mg vitamin C, 200mg phosphatidylserine, 5mg NADH
Four	60g reposition beverage in 1000 ml of water, 75g banana, 8x salt capsule, 4 L water, 1x antioxidant capsule	297/1240	60.23	13.02	0.51	2201	-	50mg Coenzyme Q, 40mg vitamin C, 200mg phosphatidylserine, 5mg NADH
Five	60g reposition beverage in 1000 ml of water, 2x sport bar, 62.5 g sweet potato and honey, 8x salt capsule, 3 L water, 1x antioxidant capsule	587/2452	106.41	19.28	7.92	2228	-	50mg Coenzyme Q, 40mg vitamin C, 200mg phosphatidylserine, 5mg NADH
Six	30g reposition beverage in 500 ml of water, 2x sport bar, 62.5 g sweet potato and honey, 8x salt capsule, 2 L water, 1x antioxidant capsule	613/2562	118	13.82	7.95	1993.6	-	50mg Coenzyme Q, 40mg vitamin C, 200mg phosphatidylserine, 5mg NADH

Note. CH = Carbohydrates; F = Fat; P = Proteins; Caf = Caffeine.

Table 2. Athlete nutritional intake before, during and after competition

Timing	Energy & Macronutrient	Stage number						Mean ± SD
		One	Two	Three	Four	Five	Six	
Breakfast	E (kcal/kJ)	1078/4506	1078/4506	1078/4506	1078/4506	1078/4506	1078/4506	1078 ± 0/4506 ± 0
	CH (g)	164.5	164.5	164.5	164.5	164.5	164.5	164.5 ± 0.0
	P (g)	50.3	50.3	50.3	50.3	50.3	50.3	50.3 ± 0.0
	F (g)	25.2	25.2	25.2	25.2	25.2	25.2	25.2 ± 0.0
During	E (kcal/kJ)	717/2996	390/1630	690/2882	297/1241	587/2453	613/2562	549 ± 169/2294 ± 705
	CH (g)	166.0	87.8	154.0	60.2	106.4	118	115.4 ± 39.9
	P (g)	12.9	7.2	15.5	13.0	19.3	13.8	13.6 ± 3.9
	F (g)	1.1	0.3	0.9	0.5	7.9	8.0	3.1 ± 3.8
	Na^+ (mg)	1442	1109	2216	2201	2228	1994	1865 ± 460
	Caffeine (mg)	22.5	0.0	0.0	0.0	0.0	0.0	3.8 ± 9.2
	CoenzQ (mg)	50	50	50	50	50	50	50 ± 0
	Vitamine C (mg)	40	40	40	40	40	40	40 ± 0
	PS (mg)	200	200	200	200	200	200	200 ± 0
	NADH (mg)	5	5	5	5	5	5	5 ± 0
Post-Stage[a]	E (kcal/kJ)	213/966	671/2805	477/1994	213/890	282/1179	213/890	348 ± 187/1454 ± 783
	CH (g)	32.9	88.6	98.2	32.9	50.8	32.9	56.1 ± 29.9
	P (g)	20.4	39.9	21.7	20.4	22.4	20.4	24.2 ± 7.7
	F (g)	0.3	12.2	0.5	0.3	0.9	0.4	2.4 ± 4.8
Lunch	E (kcal/kJ)	1050/4389	760/3177	675/2822	1045/4368	1145/ 4786	908/3795	931 ± 183/3890 ± 767
	CH (g)	108.5	68.7	63.9	216.2	178.7	160.3	132.7 ± 62.1
	P (g)	56.9	52.3	37.2	32.3	32.0	55.7	44.4 ± 11.8
	F (g)	46.3	33.5	31.4	11.6	38.7	10.3	28.6 ± 14.6
Snacks	E (kcal/kJ)	720/3010	663/2771	623/2604	0	0	0	334 ± 367/1398 ± 1536
	CH (g)	77.7	99.4	68.1	0.0	0.0	0.0	40.9 ± 45.9
	P (g)	18.4	14.9	35.5	0.0	0.0	0.0	11.5 ± 14.4
	F (g)	36.3	23.6	25.1	0.0	0.0	0.0	14.2 ± 16.1
Dinner	E (kcal/kJ)	821/3432	578/2416	510/2132	822/3436	669/2796	1247/5212	775 ± 264/3237 ± 1102
	CH (g)	113.5	94.4	68.3	97.3	18.9	23.3	69.3 ± 40.0
	P (g)	68.7	9.5	22.4	43.4	45.7	128.3	53.0 ± 42.2
	F (g)	13.4	20.8	18.2	31.5	45.2	72.0	33.6 ± 22.0

Note. PS = phosphatidylserine; CH = carbohydrates; E = energy; F = fat; P = proteins; CoenzQ = coenzyme Q
[a] Energy intake immediately after each stage.

Immediately after crossing the finish line, the athlete ingested two salt capsules plus 15 g of glutamine and 10 g of BCAA's. This was completed with food and liquid provided by the race organization. Specific nutritional value of the post-race nutrient intake is described in Table 2 along with nutritional information of each day lunch (after finishing competition), afternoon snacks (only completed in the first three stages) and dinner. Total daily nutritional intake by the athlete is summarized in Table 3 for each day of competition (breakfast, before-race, during-race, post-race, afternoon snacks and dinner). The greatest ingestion of proteins was the last day of competition, explained by the final celebration dinner.

Table 3. Total nutritional energy and macronutrients intake for each competition day

Energy & Macronutrient	Competition day					
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
E (kcal)	4617	4140	4053	3455	3761	4059
E (kJ)	19298	17305	16940	14441	15720	16966
CH (g)	663.1	603.4	617.0	571.0	519.3	499.0
CH (g/kg/day)	10.0	9.1	9.3	8.6	7.8	7.5
P (g)	227.6	147.1	182.6	159.4	169.7	268.5
P (g/kg/day)	3.4	2.6	2.8	2.4	2.6	4.1
F (g)	122.6	115.6	101.3	69.1	117.9	115.9

Note. CH = Carbohydrates; E = Energy; F = Fat; P = Proteins;

Hydration and weight loss

The athlete began the competition with a body weight of 66.2 kg and finished it with 64.9 kg. After the conclusion of each stage, a reduction in body weight was observed (Table 4). The BWL average during "Pirineos FIT" was 2.4%.

Total fluid ingestion during the stages was 2000-5000 mL provided by the reposition beverage and water and was accompanied by a Na^+ intake of 1109 – 2228 mg provided by the reposition beverage and the salt capsules (Table 4). Carbohydrate ingestion during the stages with food and supplements ranged between 1.20 and 7.74 g/100 mL and 9.27–40.65 g/h, with the minimum ingestion in the fourth stage. Details of meteorological conditions, weight loss and evolution, fluid ingestion, Na^+ and carbohydrates are provided in Table 4.

Effort perception and athlete's performance

Borg's Scale of Perceive Exertion (RPE) (21) was used to report the subjective effort perception of the athlete during each stage (Table 4). Mean heart rate

Table 4. Meteorological conditions, carbohydrate, fluid, sodium and weight control during the six competition stages

		Stage number					
		One	Two	Three	Four	Five	Six
Meteorology	T_{min} (ºC)	6.0	12.0	10.0	16.7	16.1	14.9
	T_{max} (ºC)	24	28	22	30.5	33.2	28.7
	Humidity (%)	98	94	71	77	89	98
	$Wind_{max}$ (km/h)	24	25	29	40	41	44
Weight	$Weight_{PRE}$ (kg) [a]	66.2	66.6	66.5	66.8	66.7	67.3
	$Weight_{POST}$ (kg) [b]	64.5	65.6	64.5	65.0	66.0	64.9
	BWL (kg)	1.7	1.0	2.0	1.8	0.7	2.4
	BWL (%)	2.6	1.5	3.0	2.7	1.0	3.6
Nutrients intake	Fluid intake (mL)	2200	2000	5000	5000	4000	2500
	Fluid/ hour (mL/h)	538.8	732.6	819.7	769.2	808.1	536.8
	CH (g/100 mL)	7.6	4.4	3.1	1.2	2.7	4.7
	CH intake (g/h)	40.7	32.1	25.3	9.3	21.5	25.3
	Na^+ (mg)	1442	1109	2216	2201	2228	1994
Performance	Stage result	6th	6th	7th	6th	4th	8th
	Race time (h:min)	4:05	2:44	6:06	6:30	4:57	4:40
	Distance (km) [c]	29.9	24.3	41	35	35	40
	m+	2000	1500	2600	2700	2874	1850
	RPE	13	11	15	11	17	20
	Mean HR (bpm)	150	148	141	131	142	138
	Max HR (bpm)	170	175	180	172	182	183
	Time Phase I (%)	3	23	34	74	44	68
	Time Phase II (%)	94	75	66	24	56	30
	Time Phase II (%)	3	0	0	1	0	2

Note. CH = Carbohydrates; T = temperature; $Wind_{max}$ = maximum registered wind; m+ = accumulated positive ascension; BWL = body weight loss; RPE = Borg's Scale of Perceived Exertion score. [a] Weight before each stage; [b] Weight after each stage; [c] Real distance completed by the athlete during the stages. Differences with the official distance is due to day-to-day track changes by the race organization.

(HR), maximum HR, RPE and final stage position are also described in Table 4. In the last km of stage one, the athlete suffered from light cramps and RPE was 13 ("somewhat hard"). For Stage two and four RPE score was 11 ("moderate"). Stage three was perceived with a RPE of 15 ("hard") but he had great feelings, being able to maintain pace during the stage and complete nutrient intake. Stage five was reported as the day with the best feelings, finishing in a 4th position despite a RPE of 17 ("very hard)". The athlete reported good feelings during the first km of the last stage, but the final RPE was 20 ("extenuating"), forcing him to slow down the pace.

Biochemical, hematological and hormonal parameters

Comparing blood analysis before and after the competition showed an increase in GOT-AST (71.86 %), GPT-ALT (117.86 %), iron (56.30 %), ferritin (55 %), creatine kinase (83.57 %), total testosterone (40.49 %) and reactive protein C (40 %). A reduction was observed in urea concentration (12.79 %) and BUN (12.39 %). No modifications were observed in the rest of the parameters (total cholesterol, HDL, LDL, triglycerides, thyroid hormones, cortisol, glucose, white blood cells and red blood cells).

Discussion

The aim of this study was to assess several nutrition and hydration strategies applied to an athlete that participated in an endurance trail-running race that finally led to a successfully implementation and a good competition performance.

Literature has shown a positive relationship between dietetic recommendations and sport performance (22). Adequate energetic intake improves endurance, strength and FFM (Fat-Free Mass); while uncontrolled caloric restriction depletes glycogen, critical for training and physical exercise (23). Many factors must be considered for an adequate nutritional and hydration plan: athlete's characteristics, equipment to be carried, race modality and details, environmental characteristics and the solid and liquid intake possibilities.

"Pirineos FIT" represents a nutritional and sport challenge. Therefore, it is crucial to minimize the total food carriage and provide the optimal energy and macronutrients intake in the competition. The athlete arrived to the competition well prepared, both from the nutritional and physical point of view, being completed an adequate diet and training program designed by professionals. The foods and supplements that were chosen to carry out the dietary-nutritional planning were those that the athlete usually takes and therefore is familiar to them, in order to avoid gastrointestinal problems. For the nutritional planning, energetic and nutritional recommendations were applied following specific evidence for endurance sports (24). It is worth mentioning that there were some differences between dietary carbohydrate prescription (30-60 g/h), based on literature recommendations (15-17), and the carbohydrate quantity ingested by the athlete during the race. Even the athlete accomplished the minimum carbohydrate recommended intake, he wasn't able to increase it due to the effort of self-management of food intake and race orienting. Despite that, the athlete's perceptions were always optimal and didn't prevent him of accomplish a good final position. Furthermore, no hunger or cramps were reported by the athlete, and the feelings were described as "better than in previous races".

Maybe, subjective perception of fatigue of the athlete was reduced by the ingestion of antioxidants due to the athlete's decision of avoiding caffeine intake after the first stage. As it's well documented, long duration and high intensity exercise increases the participation of oxidative metabolism, consequently increasing reactive oxidative species and oxidative stress (25). Regarding hydration, the athlete exceeded the recommendations (400-600 mL/h) in the race, avoiding dehydration with a minimal BWL except in the last stage (26,27).

Blood analysis assessment before and after competition showed habitual physiological responses to high demanding endurance efforts. Increased transaminases, testosterone, iron, ferritin and protein C are normal physiological responses after exercise (28). In fact, trained subjects tend to have significantly higher concentrations of transaminases than sedentary people (29, 30). Moreover, a high level of testosterone is a marker for an adequate physical load and long-term adaptation to exercise (28), while the increase in protein C reactive indicated an increase of physical stress during the race (31). Additionally, several studies have shown that after a moderate or intense exercise, an increase in serum iron and ferritin is observed (32). However, reduction in urea and BUN levels demonstrated that there wasn't FFM loss (33).

The good response in biochemical parameters, without no changes after the competition, the good final position of the athlete in the race (always within the first ten) and the good feelings of the athlete could be attributed (at least in part) to the appropriate dietetic-nutritional planning carried out in this study, as well as to the good body composition of the athlete, an adequate training load and an optimal age. This study adds complementary information to the existing literature (34, 35) regarding the positive influence of adequate dietary, nutritional, supplementation and hydration planning in trail-running. In addition, the dietary-nutritional strategy applied in this study can serve as a guideline for other professionals preparing ultra-endurance athletes to achieve optimal performance.

Conclusions

The application of nutrition and hydration strategies are crucial for successful performance at "Pirineos FIT", where it is necessary to reach a balance between the amount of food (weight) that the athlete has to carry and optimizing the intake of nutrients and drink. This study demonstrates the importance of an adequate dietary-nutritional planning to successfully compete in a race like "Pirineos FIT". This case study can be a useful tool for other dietitians-nutritionists who advise athletes disputing ultra-endurance trail-running events.

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Correspondence:
Eraci Drehmer
Catholic University of Valencia
Ramiro de Maetzu, 14
46900, Torrent (Valencia)
+ 96 363 74 12 (Extension 4251)
Email: eracil.drehmer@ucv.es