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Article Title: Nutrient Intake by Ultramarathon Runners: Can They Meet Recommendations?

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Nutrient intake by ultramarathon runners: can they meet recommendations?

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ABSTRACT

Purpose: The objective of this study was to investigate whether ultramarathon runners were able to meet nutrition recommendations during a training period and on a competition day. **Methods**: In preparation for a 60 or 120 km ultramarathon covering a varied terrain, male and female ultramarathon runners (n=68, age 46.5±7.1 y) reported habitual dietary intake during three independent days using a web-based 24-hour recall and questionnaires. The diet was assessed using probability of inadequacy or by qualitative evaluation using reference dietary intakes or sports nutrition recommendations. A small group of 120 km runners (n=4) was observed continuously during the race. After the race, 60 km runners (n=41) received a questionnaire to assess dietary intake and gastrointestinal (GI) distress on the race day. Spearman rank correlation coefficients (r) were applied to investigate the association between intake and general GI distress symptoms. **Results**: In men and women, habitual mean carbohydrate (CHO) intake was lower than recommended, as was mean protein intake by women. CHO intake during the race was <60 g/h in 75% of the athletes. A large variation of nutrient and fluid intake was seen. GI distress during the race was reported in 82% of the runners; severe GI distress was low. In general, moderate, mostly negative, correlations with nutrient intake were seen for GI distress. **Conclusion**: Sports nutrition recommendations for the habitual diet were not achieved. During a competition day, a large variation was found in nutrient intake; this may be related to a high incidence of GI distress.

Keywords: Sports Nutrition, Dietary Survey, Ultramarathon.

INTRODUCTION

For athletes competing in ultra-endurance activities, adequate intake (AI) of energy and nutrients during training and competition is of particular relevance to ensure optimal performance and recovery and to minimize health risks. At the same time, this population can have difficulty meeting nutrition recommendations during exercise because of a variety of reasons, in particular gastrointestinal (GI) distress (Black et al. 2012; Stuempfle et al. 2013).

For endurance athletes, recommended amounts for the habitual diet can be substantial: up to 5–12 g of carbohydrate (CHO)/kg·bw (body weight) per day, depending on training load (Burke et al. 2011), and 1.2–1.7 g of protein/kg·bw per day (Burke and Deakin 2010). Some recent studies mention athletes meeting these recommendations. For example, Ono et al. (2012) describe soccer players with a mean CHO intake >7 g/kg·bw, and Carlsohn et al. (2012) describe a mean intake of between 7.8 and 9.0 g/kg·bw by triathlon athletes.

In addition, specific recommendations are formulated for nutritional intake during and after training or competition (Potgieter 2013). Although there is some evidence supporting protein intake during exercise (Fink et al. 2012), most of the consensus has been built on sufficient protein intake before or after exercise, aiming at an intake of 1.3–1.8 g of protein (PRO)/kg·bw per day consumed as 3-4 isonitrogenous meals will maximize muscle protein synthesis (Philips and van Loon 2011). The recommended intake of carbohydrates during exercise in intensive endurance sports lasting longer than 4 h currently ranges from 60 to 90 g/h (Burke et al. 2011). However, a great deal of variation is seen in intake. For example, Pfeiffer et al. (2012) reported an intake of 35±26 g/h during a marathon, whereas Pfeiffer et al. (2009) describe runners during a 16 km run consuming 1.4 g/min of CHO, corresponding to a CHO intake of 84 g/h.

GI distress during competition is frequently experienced by runners and other endurance athletes (Jeukendrup & Oliveira 2013; Pfeiffer et al. 2012). Such complaints have several causes, including the nutrient or fluid intake (Stuempfle et al. 2013). GI distress, on the other hand, hampers the intake of adequate amounts of food during exercise.

To evaluate whether ultra-endurance athletes are able to reach those recommendations, dietary intake was assessed in ultramarathon runners during their preparation phase as well as before and during a 60 or 120 km race. The first objective of this study was to investigate whether ultramarathon runners were able to meet sport-specific dietary recommendations during a training period and on a competition day. A second objective was to assess the prevalence of GI complaints during the race and dietary factors associated with this.

METHODS

Design

The study design consisted of three parts as shown in **Figure 1**. The first part was a survey of dietary intake 2 months before the race. The second part was a questionnaire about dietary intake on a race day and GI distress during the 60 km. The third part was a continuous observational study during the 120 km. The study was performed in accordance with the Declaration of Helsinki and the survey was approved by the Medical Ethics Committee of Wageningen University. Informed consent in writing was obtained from all participants.

Population and race information

Runners, both male and female, were recruited through a promotional email by the organization of the Texel ultramarathon. Inclusion criteria were: preparation for the Zestig van Texel ("Sixty of Texel") race, age 16–70 years and ability to speak and understand the Dutch language.

The race took place on April 1, 2013, on the island of Texel, the Netherlands. The distance was 60 or 120 km on a varied track (woods, sand hills, beach, single trails and mainly flat small roads). A total of 530 athletes registered for the race (of which 31 registered for 120 km). The average temperature on the day of the race was 2.2°C, humidity was 77% and average wind speed was 6.1 m/s (22.0 km/h).

Questionnaires on dietary intake and training load

Three web-based programs were used to obtain data. Recalls of 24 hours were collected with “Compl-eat™” (Wageningen University), which is based on the five-step multiple-pass method, a validated technique to increase accuracy of dietary recalls (Conway et al. 2003). This program also allows participants to select, adapt or describe complete recipes by using household measures, standard portion sizes, weight in grams or volume in liters (Donders-Engelen et al. 1997). The daily questionnaires regarding training load and the use of dietary supplements and sports nutrition products were collected with the “vitality portal” (HAN University of Applied Sciences). The daily questionnaire consisted of five groups of questions regarding type of day (training, race or resting), type of training (game, endurance, strength, technical, core-stability, sprint or other), total amount of exercise, perceived workload on a four-point scale (light, moderate, heavy, very heavy) and dietary supplements and/or sports nutrition products used based on a pre-specified list of more than 3400 product names. If the product was not available in the list, subjects were able to fill in this themselves.

The post-race questionnaire was obtained using “Qualtrics” (The Qualtrics Research Suite, 2013. Provo, UT). To calculate energy and nutrient intakes and assign foods to food groups, the Dutch food composition database of 2010 was used (Stichting NEVO, 2010). For supplements and sports nutrition products the Dutch database for dietary Supplements (NES) was used for conversion of products into energy and nutrients (RIVM 2013).

Dietary assessment of habitual diet

From February 4 to March 4, 2013, athletes were asked to complete three unannounced non-consecutive 24-h dietary recalls in combination with a daily questionnaire over a period of 3 weeks on three separate days, selected by the researchers. Each athlete registered one Monday, Wednesday or Friday, one Tuesday or Thursday, and one weekend day. Days collected were spread evenly over the whole testing period with at least four days in between each single measurement. All questionnaires were open for 36 h and were locked automatically afterwards. If the 24-h recall and daily questionnaire were not completed, they were rescheduled in the last week of the four-week period. All 24-h recalls and questionnaires were checked by a dietician especially trained for this task using standardized procedures including a standardized weight and portion book (Donders-Engelen et al. 1997). If information was lacking, the composition of dietary supplements and sports nutrition products was retrieved from Internet or through local shops. The reported combined intake consisted of at least two complete datasets each with a 24-h recall and one questionnaire per subject, and these were converted into the amount of total energy (MJ/kcal), carbohydrates (total g and g/kg), protein (total g and g/kg), fat (total g and en%), alcohol (g), fluid (g), dietary fiber (g), vitamins including RAEs (retinol activity equivalents), B1, B2 and B6, C, D and minerals including calcium, iron, magnesium and zinc (mg/µg).

Nutritional intake and GI distress before and during the 60 km race

The day after the race, the 60 km runners received an email with a link to a post-race questionnaire asking about their food intake before and during the race and GI distress during the race. The questionnaire was a Dutch translation of the Gatorade Sport Science Institute (GSSI) questionnaire used during the 2012 Chicago Marathon (Pahnke et al. 2013.

Breakfast, pre-race nutrition and nutritional intake during the race was calculated as total energy (MJ/kcal), protein (g), fat (g), CHO (g, g/kg and g/h), fiber (g) and fluid (ml, ml/h and ml/kg) based on general sports nutrition guidelines (Burke et al. 2011; Kerksick et al. 2008; Kreider et al. 2010; Sawka et al. 2007; Tarnapolsky et al. 2005). GI distress was measured on a nine-point scale ("no problem at all" to "the worst it has ever been") and mentioned with a score >0. If a complaint had a score above 5, it was considered as serious. For vomiting and intestinal bleeding, each value above 0 was considered a serious complaint.

Observation during 120 km race

In a subgroup of four 120 km runners, nutritional intake was actively monitored during the race. Each food was uniquely labeled and listed, and pictures were taken of ingredient declarations.

Height (Cescorf® stadiometer, Porto Alegre, Brazil) and body weight (Seca scale S760 mechanical) were measured the day before at the end of the afternoon and directly after the race. Each runner was accompanied by a cyclist who used a voice recorder to report the use of all products. All collected beverages or food items were checked afterwards with measuring cups and kitchen scales for remaining content (ml or g) to calculate total consumed content as energy (total kJ/kcal and energy/hour), CHO (g/h) and fluid (ml/h).

Data analysis

All calculations were performed in Excel (2007) and SPSS (IBM SPSS Statistics, version 20). Energy and selected nutrients were checked for normal distribution based on histograms and normal curve, skewness and kurtosis. Dietary intake was expressed as mean ± standard deviation (SD) or median with 25thth–75th percentile. If an estimated average requirement (EAR; based on Health Council of the Netherlands guidelines of Nordic Nutrition Recommendations) was available (Murphy, 2008), group mean or log transformed mean was used to evaluate the diet based on probability of inadequacy (Van Staveren et al. 2012). To this end, the (SD-corrected) area under normal curve (probability of inadequacy) was calculated (Murphy, 2008). In all other cases, reference dietary intakes, AIs and available sports nutrition recommendations, based on international literature or Nordic Nutrition Recommendations, were used for qualitative comparison with the group median to evaluate dietary intake.

Nutritional intake based on questionnaires during the 60 km race was reported as group mean ± SD and min–max for males, females and the total group. Frequency tables were used for qualitative assessment based on sports nutrition recommendations using percentages below, equal to and above recommendations. To evaluate data on single GI symptoms, Spearman rank correlation coefficient was used, because scores on GI symptoms were recorded mainly on the low end of the scale (score 0–9) and not normally distributed, using a P-value of <0.05 for significance.

Data of the observational study in 120 km were presented per individual and as mean intake ± SD.

RESULTS

Complete food consumption data (records of at least 2 days) were available from 68 subjects. Nutritional intake and GI distress before and during the race was based on 41 subjects. Initially, seven subjects were followed during their 120 km race; however, because of drop-out (n=2) and incomplete recording during the race (n=1), data relating to only four male subjects were considered in this paper. Group characteristics per study part are shown in **Table 1**.

Food consumption survey during a training period

In total, 197 recall days were collected, of which 155 days for males and 42 for females. Total recall days consisted of 64% training days, 30% resting days and 6% competition days.

In total, 235 dietary supplements and sports nutrition products were registered in 20 different categories. Roughly one-third of the subjects did not use any of these products. Dietary intake for males and females is shown in **Table 2**. For both males and females, inadequate intake was highest for retinol activity equivalents and vitamin D; however, inadequate intakes were seen also for vitamin B1, B6, C (males and females) and for calcium, iron and zinc (females). For males, a low risk for the prevalence of low intakes was shown based on median intakes regarding to the sports nutrition recommendation for PRO (1.2–1.8 g/kg·bw) and RDI for fluid, and AI for fat (en%) vitamin B2 and magnesium. For females, the low risk for prevalence was shown based on recommended daily intake for PRO (0.8 g/kg·bw), fat, fluid, vitamin B2 and magnesium. No statement could be made regarding CHO (5–7 g/kg·bw) and PRO (1.8 g/kg·bw for males and 1.2–1.8 g/kg·bw for females) based on the suggested sports nutrition recommendations or regarding fiber based on AI because median levels were below recommendations and no EAR was available. Both males and females had difficulties meeting the lower sports nutrition recommendations taken from the literature for CHO (>5 g/kg·bw) and partly also PRO (>1.2 g/kg·bw).

Nutritional intake and GI distress before and during the 60 km race

Breakfast was consumed on average 3–4 h before the start of the race. Average total energy intake of the breakfast was 2.8±1.2 MJ. This consisted of PRO (21±13 g), fat (17±19 g), CHO (102±49 g), dietary fiber (7±4 g) and fluid (0.63±0.3 L). In between breakfast and the start of the race, 27 runners (65.9%) ate a snack or a small meal containing 0.9±1.0 MJ of energy, generally consisting of PRO (4±5 g) fat (2±3 g), CHO (45±52 g), fiber (2±3 g) and fluid (0.23±0.39 L). Most energy during the race was provided by carbohydrates, on average 274±133 g, contributing to the total energy intake of 4.9±2.3 MJ. Mean fluid intake during the race was 2.0±1.5 L.

In **Table 3,** the percentage of runners who did or did not meet recommendations is specified. Of the runners, 87.8% managed to take in >1.0 g/kg·bw of CHO and >0.15 g/kg·bw of PRO before the race. Furthermore, 70.6% consumed more than 8.0 ml/kg·bw of fluid. During the race, 24.4% of the group achieved the recommendation to take ≥60 g of CHO per hour and 14.6% consumed >500 ml/h of fluid.

The percentages of self-reported complaints are shown in **Table 4**. In total, 82.9% of the athletes (27 men and seven women) reported some GI symptoms during the race. Severe GI symptoms were reported by 7.3% (two men, one woman). Men (81.8%) and women (87.5%) reported relatively equal amounts of discomfort. The most common complaints were an urge to urinate (56.1%), belching (46.3%) and flatulence (36.6%).

All significant single-nutrient GI correlations are shown in **Table 5**, indicating a low to moderate relationship. All correlations are negative except for the two associations found for fiber, showing that a higher fiber intake is associated with a higher frequency of nausea and an urge to defecate.

Observation during 120 km race

Runners completed the race in 9:30:39 to 11:59:24 h. Total energy intake ranged from 1.45 MJ to 5.51 MJ, with all runners using sport nutrition products during the race and two runners relying solely on sports nutrition products without basic food products. Lower energy intake was seen in the two fastest runners. All runners reported average CHO intakes >30 g/h and fluid intakes >350 ml/h. Body weight change after the race ranged between –4% and +1%. The fastest runner lost the most weight and the slowest runner gained weight in comparison to the pre-race weight measured the day before in the afternoon. The energy and CHO and fluid intake of four runners during the 120 km observation are shown in **Table 6**.

DISCUSSION

So far, only a few studies specifically addressed dietary intake and supplement use by ultramarathon runners (Fallon et al. 1989; Glace et al. 2002; Hoffman & Wegelin, 2009; Knechtle et al. 2008; Moran et al. 2011). The present study investigated the habitual diet including use of sport-specific products and dietary supplements during a training phase and nutrient intake before and during competition. Despite the low number of subjects, the observation of the 120 km run can serve as case report illustrating the practice of eating and drinking during an ultramarathon. Our general study population was relatively large compared to previous reports and consisted of 68 (training phase) and 45 (race) men and women. Their average age (around 46 y) and daily training activity (generally between 1 and 2 h of training per day) was in line with those reported in the literature for recreational ultra-runners (Fallon et al. 1989; Glace et al. 2002; Hoffman & Wegelin, 2009; Knechtle et al. 2008). Quite remarkably, data on nutritional intake of women participating in ultra-endurance running appear to be limited to one case study (Moran et al. 2011).

We found that CHO intake during training periods was generally lower than the recommended 5 g/kg·bw for endurance athletes with moderate training load (Burke et al. 2011; Potgieter, 2013), in both men and women. Although not shown, the subjects reported an average training intensity on total group level of 2.5 based on a four-point scale, indicating that they experience their total training load as being between moderate and heavy. The largest proportion of days covered consisted of endurance training days (42%) or resting days (24%), and 14% of days involved non-running-specific exercise. Hence, in our opinion, recommendations for moderate endurance exercise would be the most applicable for this group, corresponding to a range from 5 to 10 g/d.

For women only, PRO intake did not meet the recommendations. Daily CHO intake (g/kg·bw) was lower in women than in men, which can be explained at least partly by their lower total energy intake and lower total energy expenditure based on a shorter average training duration per day compared to men (males: 118±78 min/day; females: 101±82 min/day).

Twenty-four hour recalls and questionnaires are known to underestimate dietary intake (Freedman et al. 2004), and therefore actual dietary intake presented in **Table 2** might be higher. The estimate mean intake is consequently not biased, but the precision is influenced and the distribution of measured intake is artificially widened because of random between-person errors and systematic and random within person errors (van Staveren et al. 2012). The precision of the mean estimate (Dt) of a group can be improved by increasing the number of subjects or the number of days (Beaton et al. 1979). A low percentage indicates a greater likelihood that the combination of the number of respondents and the number of replicate measurements leads to the required precision. A Dt of 10–20% for single-nutrient intakes is considered to be reliable (Willet, 2012). Post-hoc analyses indicated that Dt was lower than 20% for all nutrients reported in **Table 2**, except for alcohol.

Fluid intake during the race was generally low (based on questionnaires and observation). Although personal fluid needs are highly variable (Potgieter, 2013), we selected the range for fluid intake suggested by Kreider et al. (2010): 0.5–2.0 L/h of fluid. However, weather conditions made it almost impossible to match the selected fluid recommendations during competition and we did not manage to assess the pre- and post-race weight of all subjects to estimate fluid balance. Therefore, it is difficult to draw hard conclusions based on information found in the literature. Pre- and post-race body weight was measured in the small group of 120 km runners (n=4). Because of practical reasons, pre-race body weight was measured the day before, at the end of the afternoon. Hence, the reported change in body weight could have been biased by foods and fluids consumed between weighing and the start of the race. However, the largest proportion of body weight change is can be attributed to the race per se. For example, the fastest runner did experience GI-problems during the race which did affect his diet and fluid plan negatively. The post-race body weight measurement was close to the actual time of finishing, and therefore reflected the true post-race body weight.

The mean CHO intake (67.2 g/h) of the 120 km runners was close to recommendations (Burke et al. 2011). This figure is much higher than described by Fallon et al. in 1989, who reported an intake of 21.2 g/h during a 100 km race. They included seven subjects that were continuously observed. The large variation in intake may partly account for the difference in findings. However, in our opinion, the largest part of the relative low CHO intake measured by Fallon et al. resulted from differences in CHO recommendations between both periods (1989 vs 2011).

Our 60 km runners reported a CHO intake of 24.8 g/h, which was lower than previous findings using a questionnaire (Glace et al. 2002). Differences may be explained at least partly by differences in running speed, which also determines CHO demand. In the studies reported by Fallon et al. (1989) and Glace et al. (2002), average speed was lower than recorded in the present study; in our opinion, this makes it easier to consume higher amounts of CHO without resulting in a notable number of GI complaints. It is also possible that the low fluid intake influenced CHO intake. This may be due to the fact that athletes had expected to receive CHO from fluids according to their planned intake schedule, which may not have been adapted to the cold circumstances.

Furthermore, the differences in our study between the 60 km and 120 km runners may have methodological causes. Questionnaires are more practical and cost effective. Individual monitoring, on the other hand, including recording of spilling and actual use, is far more accurate.

GI discomfort may impact the ability to eat or drink. In our study, we used a questionnaire post-race to obtain data on GI distress on the race day. All values >0 were included as GI symptom. Most GI complaints were ranked "moderate." Therefore, it is questionable whether these GI complaints directly influenced performance. Severe GI symptoms were rare, maybe because of the distance and environmental conditions and, in this case, probably not having a notable impact on group results. GI complaints are more common during races over longer distances (Stuempfle et al. 2013).

Most studies used questionnaires during the race at provision/check points (Colombani et al. 2002; Glace et al. 2002; Moran 2011) or continuous observation (Fallon et al. 1998). Linderman et al. (2003) used a 48-h recall at the end of the race day, possibly giving a better insight in dietary intake in comparison with a questionnaire taken the day after.

Self-reported moderate GI complaints (82%) are in the upper level compared to those from other studies (Rehrer et al. 1992). We categorized these complaints as moderate based on our nine-point scale. Other studies often assessed only the presence of complaints (Glace et al. 2002) or mentioned only severe GI complaints (Pfeiffer et al. 2012). Therefore it is difficult to compare results. Glace et al. (2002) reported a lower incidence of GI distress (50%) and no relation with nutrient intake during a 160 km race, but running speed in our study was higher (10±1.0 km/h) in comparison to that reported by Glace et al. (6.6 km/h), possibly contributing to the higher incidence of GI distress. Although Glace et al. used a questionnaire, in the specific section of the questionnaire respondents only had to mention if symptoms where present. In our study, all symptoms were pre-structured. Therefore, it is possible that Glace found a lower incidence, because complaints were not recognized as such; on the other hand, our method did rely on memory and the method of Glace et al. did not.

The most common complaint found in this study was the urge to urinate, but this was not associated with fluid intake. All GI–nutrient correlations were moderate, around 0.30–0.40, and all associations found were negative except for fiber. Therefore, higher nutrient intake, except fiber intake, was in general associated with lower frequency of GI distress. Of course, the question remains if this is a result of higher nutrition intake or if those subjects experience fewer complaints and therefore can eat more.

In conclusion, men and women did not meet CHO recommendations during training, neither did women for PRO. CHO, PRO and fluid intake on a race day before the race was considered sufficient. CHO intake during the race was lower than recommended for 60 km runners. The small group of 120 km runners showed that intakes higher than the recommended range of 60–90 g/h are possible. The present study adds to our knowledge on dietary intake by ultramarathon runners because of the relatively large number of participants included and the different methods used.

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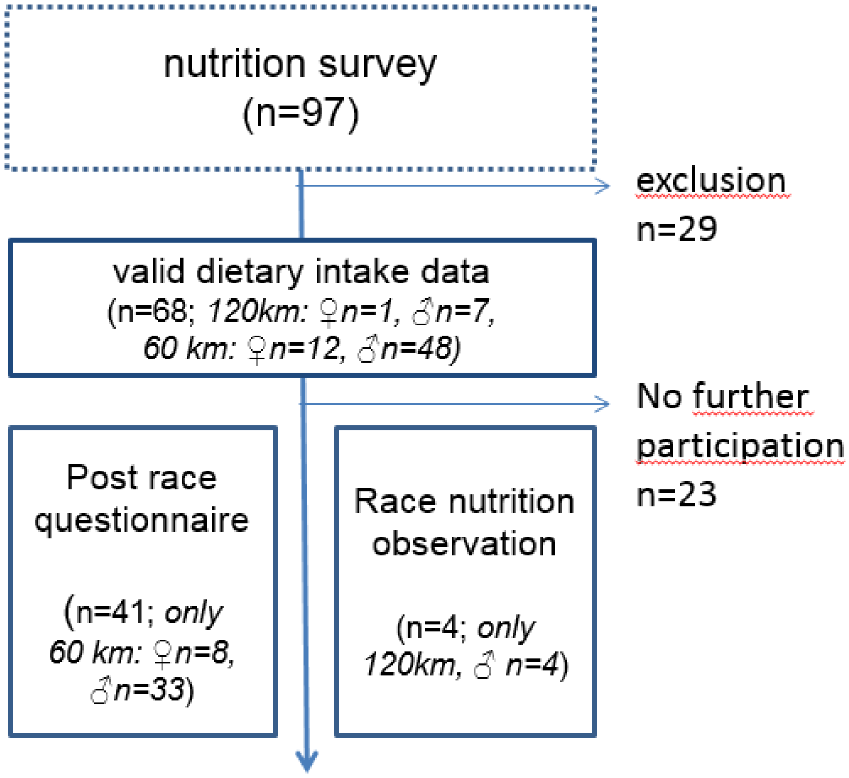

Figure 1. Study participant flow: after start of the survey 68 subjects with 2-3 complete datasets were included. For the follow up with a questionnaire only runners of the 60 km were included. For the continuous observation only runners of the 120 km were included.

Table 1. Group characteristics

		Survey (n=68)		Questionnaire (n=41)	Observation (n=4)
		60 km	*120 km*	*60 km*	*120 km*
Gender (n)	Male	48	7	33	4
	Female	12	1	8	0
Age (year)		46.5±7.2	46.6±6.3	47.3±6.8	46.5±6.8
Weight(kg)		71.7±10.8	73.0±7.0	71.7±10.1	71.8±9.6
Height (cm)		178.4±9.5	181.8±6.5	171.5±27.8	167.1±29.6
Exercise (min/day)		83±52	111±70	48±48	108±83

Table 2. Habitual energy and macro-nutrient intake of male and female ultramarathon runners.

Nutrients	Male (n=54)					Females (n=14)				
	Mean±SD	Median (25th-75th)	EAR/ RDI/ AI	POI (%)	Prevalence of inadequate intakes	Mean±SD	Median (25th-75th)	EAR/R DI/ AI	POI (%)	Prevalence of inadequate intakes
Energy (MJ)	11.3 ±2.6	11.2 (9.3-13.4)	-	-	-	8.8±2.1	8.4 (7.4-9.7)*	-	-	-
Energy (Kcal)	2700±630	2676 (2210-3186)	-	-	-	2105±493	1992 (1770-2306)*	-	-	-
CHO (g)	327±89.3	332 (265-375)	-	-	-	258±78.1	231 (208-274)*	-	-	-
CHO (g/kg)	4.4±1.3	4.4 (3.6-4.9)	**2.9***	3	3%	4.5±1.3	4.0 (3.5-5.0)*	**2.9***	0	0%
			5■	78	ns			5■	83	ns
			7■	100	ns			7■	100	ns
PRO (g)	93.9±23.2	91.1 (80.1-112)	-	-	-	72.5±21.3	69.3 (58.2-81.9)	-	-	-
PRO (g/kg)	1.3±0.3	1.3 (1.0-1.5)	**0.6***	0	0%	1.3±0.3	1.2 (1.0-1.4)	**0.6***	0	0%
			0.8◊	0	low risk			0.8◊	2	low risk
			1.2■	33	low risk			1.2■	40	ns
			1.8■	100	ns			1.8■	100	ns
FAT (g)	97.1±39.8	95.3 (68.7-116)	-	-	-	76.1±26.6	72.6 (59.0-96.6)	-	-	-
FAT (en%)	31.0±8.8	30.7 (25.0-36.5)	20♦	2	low risk	32.1±8.3	31.8(27.6-38.8)	20♦	2	low risk
Alcohol (g)	11.5±16.1	6.0 (0.00-21.1)*	-	-	-	4.6±5.7	2.6 (0.0-7.3)*	-	-	-
Fluid (kg)	2.9±0.9	2.9 (2.3-3.3)*	2.5♦	33	low risk	2.8±1.2	2.7 (1.7-3.3)*	2.0♦	22	low risk
Fibre (g)	28.0±7.6	26.8 (23.6-32.0)*	37.8♦	100	ns	27.2±10.4	23.7 (19.3-34.2)	29.4♦	23	ns
RAE (µg)	378±184	335 (243-464)*	620*	97	97%	527±267	469 (297-677)	530*	51	51%
Vit. B1 (mg)	5.2±15.9	1.4 (1.0-2.0)*	**0.8***	17	17%	5.6±10.6	1.5 (1.0-3.1)*	**0.8***	9	9%
Vit. B2 (mg)	7.2±22.3	1.8 (1.2-2.7)*	1.1♦	21	low risk	6.1±10.5	2.7 (0.9-3.8)*	1.1♦	11	low risk
Vit. B6 (mg)	4.9±9.0	1.7 (1.4-3.0)*	**1.1***	6	6%	6.3±7.6	2.9 (1.4-8.6)*	**1.1***	15	15%
Vit. C (mg)	233±143	264 (90.8-259)*	**60***	0	0%	357±389	210 (129-386)*	**50***	0	0%
Vit. D (µg)	4.7±4.8	2.8 (1.6-6.5)*	**7.5***	94	94%	3.7±2.1	3.4 (2.0-5.5)	**7.5***	99	99%
Calcium (µg)	1154±470	1114 (796-1355)*	**500***	0	0%	1066±508	932 (675-1542)	**500***	8	8%
Iron (mg)	15.0±5.7	13.9 (10.9-16.6)*	**7***	0	0%	15.7±8.1	12.8 (9.7-18.3)*	**10***	12	12%
Magnesium (mg)	472±144	458 (354-564)*	350♦	7.5	low risk	454±128	448 (345-543)	280♦	2	low risk
Zinc (µg)	13.3±5.9	12.2 (9.6-15.1)*	**6***	0	0%	12.2±5.8	10.3 (8.2-17.5)	**5***	4	4%

Percentages of the group that corresponded equally to the recommendation and the percentages above or below this range was displayed.
*Eating moments before the race consist of total eating moments before the start of the race.
Recommendations before race: CHO: Kerksick et al. (2008), PRO: Tarnapolsky et al. (2005) and Fluid: combined guidelines proposed by Sawka et al. (2007). Both recommendations of Sawka et al (2007) based on 3-4 hour 5-7ml/kg.bw before exercise and 2 hours before 3-5 ml/kg.bw were combined into one range of 8-10 ml before competition
Recommendations during race: CHO Burke et al. (2011): and Fluid: Kreider et al. (2010).

Table 3. Carbohydrate, protein and fluid intake per kg before and per hour during 60 km ultra-marathon based on a questionnaire.

Nutriënt	Recommendation	Total (n=41)			Male (n=33)			Female (n=8)		
		% equal	*% <*	*% >*	*% equal*	*% <*	*% >*	*% equal*	*% <*	*% >*
Before race*										
CHO (g/kg)	1-2	41.5	12.2	46.3	36.4	12.1	51.5	62.5	12.5	25.0
PRO (g/kg)	0.15-0.25	24.4	7.3	68.3	21.2	6.1	72.7	25.0	12.5	62.5
Fluid (ml/kg)	8-10	14.6	29.3	56.1	15.1	27.3	57.6	12.5	37.5	50.0
During race										
CHO (g/h)	60-90	22.0	75.6	2.4	21.2	72.7	6.1	12.5	87.5	0
Fluid (ml/h)	500-1000	12.2	85.4	2.4	15.2	81.8	3.0	0	100	0

Percentages of the group that corresponded equally to the recommendation and the percentages above or below this range was displayed.
*Eating moments before the race consist of total eating moments before the start of the race.
Recommendations before race: CHO: Kerksick et al. (2008), PRO: Tarnapolsky et al. (2005) and Fluid: combined guidelines proposed by Sawka et al. (2007). Both recommendations of Sawka et al (2007) based on 3-4 hour 5-7ml/kg.bw before exercise and 2 hours before 3-5 ml/kg.bw were combined into one range of 8-10 ml before competition
Recommendations during race: CHO Burke et al. (2011): and Fluid: Kreider et al. (2010).

Table 4. Percentage of self reported complaints during 60 km based on a questionnaire (n=43).

	%	no complaints	complaints	severe complaints
High respiratory and stomach complaints	Reflux	79.1	16.3	4.6
	Heartburn	90.7	9.3	0
	Belching	53.5	41.9	4.6
	Bloating	81.4	16.3	2.3
	Stomach cramps	81.4	14.0	4.6
	Vomiting	95.4	-	4.6
	Nausea	74.4	20.9	4.7
Lower bowel complaints	Intestinal cramp	90.7	9.3	0
	Flatulence	62.8	34.9	2.3
	Urge to defecate	81.4	16.3	2.3
	Side ache	88.4	11.6	0
	Abdominal pain	88.4	9.3	2.3
	Loose of stool	95.4	4.6	0
	Diarrhoea	97.7	2.3	0
	Intestinal bleeding	100	-	0
Other	Dizziness	95.3	4.7	0
	Headache	88.4	11.6	0
	Muscle cramps	67.4	30.3	2.3
	Urge to urinate	44.2	46.1	9.7

Table 5. Significant correlations (r) for nutrients and GI distress based on a questionnaire (n=43).

		Energy intake	Carbohydrate intake	Fiber intake	Fluid intake
High respiratory and stomach complaints	Heartburn	-0.31, p=0.04	-0.33, p=0.03		-0.33, p=0.03
	Belching				-0.34, p=0.03
	Vomiting	-0.40, p=0.01	-0.41, p=0.01		-0.36, p=0.02
	Nausea			0.31, p=0.04	
Lower bowel complaints	Intestinal cramp				-0.36, p=0.02
	Flatulence				
	Urge to defecate			0.45, p=0.01	-0.35, p=0.02
	Side ache				-0.38, p=0.01
	Loose of stool	-0.35, p=0.02	-0.34, p=0.03		
	Diarrhea	-0.34, p=0.03	-0.31, p=0.04		-0.35, 0.02
Other	Dizziness	-0.34, p=0.03	-0.31, p=0.05		-0.29, p=0.06
	Headache				-0.39, p=0.01
	Urge to urinate	-0.40, p=0.01	-0.31, p=0.05		

Only significant (p≤0.05) correlations are shown. No correlations for single nutrients and GI distress are shown for reflux, bloating, stomach cramps, flatulence, abdominal pain, intestinal bleeding and muscle cramps

Table 6. Mean intake and range of energy, carbohydrate and fluid per hour.

	Ranking	Weight (kg)	Weight loss or gain (%)	Race time (hours)	Velocity (km/hour)	Total energy intake MJ (Kcal)	MJ/hour (Kcal/hour)	CHO/hour (g)	Fluid/hour (ml)
Runner 1	1st	70.3	- 4%	9:30:39	12.6	10.5 (2496)	1.1 (263)	61 (8-114)	530 (130-827)
Runner 2	3rd	59.4	- 3%	10:54:26	11.0	6.1 (1457)	0.6 (134)	31 (11-57)	392 (178-669)
Runner 3	8th	81.1	0%	11:39:55	10.3	23.1 (5514)	1.8 (428)	108 (39-135)	609 (259-805)
Runner 4	13th	81.0	+1%	11:59:24	10.0	15.3 (3656)	1.3 (305)	69 (7-119)	587 (120-1230)

CHO and Fluid intake/hour are shown as mean intake and range per hour. Low values can be the result of incomplete hour registration due to finishing the race.