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From pre-competition prep to recovery: analysing cyclists' dietary choices and gastrointestinal health in an endurance competition

De la preparación previa a la competición hasta la recuperación: análisis de las elecciones dietéticas y la salud gastrointestinal de los ciclistas en una competencia de resistencia

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ABSTRACT

Introduction: In recent years, long-distance events and mountain biking or MTB have seen a growth in both the number of events organised and number of participants. In this type of endurance event, proper nutritional and hydration planning is essential to maintain optimal sporting performance and reduce the incidence of gastrointestinal problems. This study aims to determine the dietary intake and compliance with nutritional recommendations of athletes in two endurance competitions at different times: pre-competition, during competition and post-competition, and as well, assess the incidence of gastrointestinal discomfort.

Methods: An observational and cross-sectional study was carried out on the consumption of liquids, food, and supplements in 40 MTB athletes participating in Gran Fondo Sierra de Alcaraz (Castilla la Mancha, Spain), in two different distances: Long-distance (143 km) and Marathon (64 km). The mean age was 44.21 ± 11.88 years, and body mass was 74.05 ± 11.86 kg. Data was registered by self-completing a validated questionnaire (NIQEC) by each participant after completing the competition.

Results: The mean intakes during the competition were 186.2 ±92.3 kcal/h for energy, carbohydrate (CHO) 41.1 ±21.2 g/h, fluids 516.6 ±177.7 ml/h and sodium 181.9 ±175.6 mg/h. Significant differences were found, with energy, CHO, and sodium intake being higher in the long-distance group. Additionally, a trend toward a negative correlation was observed in the long-distance group between CHO intake during the race and finishing time.

Conclusions: Mean intakes of CHO and sodium were lower than scientific recommendations but higher in the long-distance competitors, but fluids intake met these recommendations in both groups.

Keywords: nutrition; endurance; sport supplements; foods; Cyclists; NIQEC.

RESUMEN

Introducción: En los últimos años, las pruebas de larga distancia y de ciclismo de montaña o BTT han experimentado un crecimiento tanto en el número de eventos organizados como en el número de participantes. En este tipo de pruebas de resistencia, una adecuada planificación nutricional y de hidratación es esencial para mantener un rendimiento deportivo óptimo y reducir la incidencia de problemas gastrointestinales. El objetivo de este estudio es determinar la ingesta dietética y el cumplimiento de las recomendaciones nutricionales de los deportistas en dos competiciones de resistencia en diferentes momentos: pre-competición, durante la competición y post-competición, así como evaluar la incidencia de molestias gastrointestinales.

Metodología: Se realizó un estudio observacional y transversal sobre el consumo de líquidos, alimentos y suplementos en 40 deportistas de MTB participantes en la prueba Gran Fondo Sierra de Alcaraz (Castilla la Mancha, España), en dos distancias diferentes: Larga distancia (143 km) y Maratón (64 km). La edad media fue de 44.21 ± 11.88 años y la masa corporal de 74.05 ± 11.86 kg. Los datos se registraron mediante la autocumplimentación de un cuestionario validado (NIQEC) por cada participante tras finalizar la competición.

Resultados: Las ingestas medias durante la competición fueron de 186.2 ±92.3 kcal/h de energía, hidratos de carbono (CHO) 41.1±21.2 g/h, líquidos 516.6 ±177.7 ml/h y sodio 181.9±175.6 mg/h. Se encontraron diferencias significativas, siendo la ingesta de energía, CHO y sodio mayor en el grupo de larga distancia. Además, se observó una tendencia hacia una correlación negativa en el grupo de larga distancia entre la ingesta de CHO.

Conclusiones: La ingesta media de CHO y sodio fue inferior a las recomendaciones científicas, pero superior en los competidores de larga distancia, aunque la ingesta de líquidos cumplió con estas recomendaciones en ambos grupos.

Palabras clave: nutrición; resistencia; suplementos deportivos; alimentos; ciclistas; NIQEC.

HIGHLIGHT MESSAGES

- Proper planning of carbohydrate (CHO), fluid, and sodium intake before, during, and after mountain bike (MTB) competitions is essential to optimize athletic performance and reduce gastrointestinal complaints.
- Cyclists participating in the Gran Fondo Sierra de Alcaraz consumed CHO and sodium levels below scientific recommendations during the competition, which could limit their performance capacity in prolonged events.
- A negative trend was observed between CHO intake during the competition and finishing time among long-distance cyclists, suggesting that higher consumption could improve performance outcomes.
- Long-distance cyclists showed greater awareness of the importance of pre-competition fluid and CHO intake but still faced challenges in meeting intra-competition recommendations.

INTRODUCTION

Cycling is the second most popular sport in Spain according to the 2022 sports habits survey[1]. In terms of competitive cycling the Real Federación Española de Ciclismo (RFEC) registered 73.496 licenses at the end of the year 2023[2]. The Union Cycliste Internationale (UCI) recognises 11 competition disciplines: Road, Track, Mountain Bike (MTB), BMX freestyle, BMX Racing, Indoor cycling, Trials, Cyclo-cross, Gravel, Cycling Esports and Para-cycling[3]. MTB is a discipline off-road with a wide variety of terrain and obstacles like rocks, branches, ruts, and tree roots[4]. There are some disciplines of MTB, based in the distance and specific characteristics of the track (i.e.: XCO-Olympic cross country, XCM-Cross country marathon, XCUM-Cross country ultramarathon …) each one with individual rules of the RFEC[5].

Optimal physiological conditioning for the cyclists is essential for a good performance because all three energy energetic pathways are used: phosphagen (explosive efforts up to 6s), glycolytic (medium intensity efforts >6s up to 1 min) and oxidative phosphorylation (efforts >1 min)[6]. It has been widely scientific evidence about the glycogen paper in endurance athletes, as a fuel source and its depletion as a limiting factor in performance[7]. In submaximal long-distance cycling events there will be varied intensities from moderate (i.e 65% VO_2max) to high intensity exercise (85% VO_2max), caused by changes in environmental conditions, terrain, peloton race dynamics and in the final sprint which imply an increase in the use of muscle and liver glycogenesis, making carbohydrates (CHO) metabolism predominant[8].

Diet and timing play special role in a cyclist's nutritional preparation. The importance of CHO consumption prior to a competition or training has been widely established[9]. Current guidelines recommend a high-CHO-containing meal of ~1-4g/kg >60 min prior to exercise[9], considering important factors the amount, type of CHO and avoid fat or protein to minimise the risk of gastrointestinal (GI) discomfort[10]. The recommendations when cycling at a high intensity for more than 120-150 min, recent research suggests to consume 120g/hour of exercise with CHO from different sources (glucose, fructose, solid, liquid or semisolid) to optimise their absorption and subsequent utilisation[6]. However this requires athletes to train their digestive system to avoid GI discomfort[11]. Post-exercise recommendations for CHO intake are aimed for maximally replenishing glycogen stores, the recommended amount of CHO post-exercise is 1-1.2 g/kg, in case that cyclist cannot reach this amount, is interesting the co-ingestion of protein to complete the recovery meal (i.e.: 0.8 g CHO/kg and 0.4 g proteinkg[12].

Another important aspect in terms of performance is the state of hydration. Sweat rates can reach 5L/h in fit athletes but 0.5-1.5L/h is more common[6]. The recommended volume and rate of fluid consumption during exercise are dependent on the athlete's individual sweat rate, but the American College of Sports Medicine (ACSM) recommends 4 hours prior to exercise small and slowly drink beverages (~5-7 mL/kg). In addition, is recommended to consume 0.4 to 0.8 L/h with 300–600 mg/h of sodium during prolonged exercise of more than 2 hours, in order to reduce the risk of dehydration and prevent hyponatraemia[13]. It is also recommended post-exercise to consume 150% of the fluid lost based on body mass, taking into account the incorporation of sodium (>60 mmol/L) to facilitate greater fluid retention[13].

The use of ergogenic aids could improve the performance in MTB, being caffeine one with most scientific evidence in dose of 3–6 mg·BM−1 45-60 before exercise or in smaller doses throughout the ride[14]. Considering the high nutritional demands of endurance cycling and all the factors surrounding peak f performance, including dietary habits, ergogenic aids consumption, timing and hydration, the present study aimed to determine the dietary intake and compliance with nutritional recommendations of cyclists in two MTB-endurance competitions at different times: pre-, during and post-competition, as well as assess the incidence of GI complaints.

METHODOLOY

Study Design

This is an observational and cross-sectional study on the consumption of nutrients, fluids, and supplements and the occurrence of gastrointestinal discomfort by cyclists participating in the MTB Gran Fondo Sierra de Alcaraz, Spain (October 2023). The competition consisted in two MTB competitions: Gran Fondo with 140 km distance (5h 30 min to 9 hours); MTB Marathon with 62km distance (2h 30 min to 5 hours)[15]. The manuscript is presented according to the STROBE-nut guidelines for nutritional epidemiology, an extension of the general STROBE recommendations for observational research.

Study Population

The study population was selected by non-probability, non-injury, convenience sampling, as participants were recruited by email from the organising institutions. The eligibility criteria established were 1) Participants must have completed the competitions in one of its two distances (143 or 64 km); 2) -Not suffered from any injuries or illnesses in the six months prior to the survey; 3) complete the NIQEC questionnaire.

Procedure

To select the study sample organisers of the MTB Gran Fondo Sierra de Alcaraz 2023 were contacted by e-mail to inform them of the characteristics of the study and to request their collaboration. After agreeing to participate, the cyclists could fill the questionnaire voluntarily, electronically and anonymously. The questionnaire was sent out at two time points: on the race day (5 October 2023) and two days later via race's newsletter. With the cooperation of the event organisers, the link reporting to the NIQEC questionnaire with instructions on how to fill it in was made available to the participants.

Study Variables - Instruments

A online self-administered NIQEC questionnaire, developed specifically to obtain fluid, food, and supplement intake and to determine the incidence of gastrointestinal complaints in endurance competitions, was used[16]. The questionnaire consists of 50 questions and contains five main sections: (1) sociodemographic data; (2) sports data; (3) food, liquid, and supplement intake in the hour before, during, and in the hour after the competition; (4) possible gastrointestinal complaints; and (5) dietary–nutritional planning of the test. The coding of the variables and the estimation of energy and macronutrients was carried out by a trained dietitian–nutritionist, using the Spanish Database of Food Composition (BEDCA) and following the guide to perform the nutritional estimation from the NIQEC questionnaire developed by the authors of the questionnaire[17]. The questionnaire can be viewed in the Supplementary Material.

Statistical Analysis

The statistical analysis was run with the statistical package STATA 15 (College Station, TX). Only completed questionnaires were analysed with no imputation for missing data. The mean and standard deviations of the variables were calculated. Normality of the variables was verified by the Shapiro Wilk test. To analyse differences according to finishing time, Anova or Kruskal Wallis tests were used, depending on the normality of the variables. An alpha level of $p<0.05$ was established. The relationship between finishing time with demographics, training characteristics, and pre-, intra-, and post-competition intake on each distance, was evaluated using Pearson's correlation coefficients. The effect sizes were calculated as Cohen's d and interpreted using sport-specific thresholds for highly trained population:1 trivial (<0.25), small (0.25-0.5), moderate (0.5-1.0), and large (>1.0). For variables that showed asymmetric distribution, the median and Mann-Whitney U test were used. The effect size was estimated with the rank-biserial correlation coefficient and interpreted as follows: 2 small= 0.10-0.29, medium= 0.30-0.49, large= >0.50.

RESULTS

A total of 210 athletes were invited to participate across two endurance competitions. Of these, 40 male cyclists (20 to 67 years old) participants voluntarily completed the full questionnaire and met the inclusion criteria. Table 1 provides participants characteristics information on the age, basic anthropometric characteristics, years of sporting experience and comptetion finishing times of the study participants.

Table 1. Descriptive characteristics of the participants in the study.

	Overall (n=40)		Cycling modality race: Marathon distance (n= 20)	Cycling modality race: Long-distance(n= 20)	*p*
	n	%	%	%	
BMI (kg/m²)					
LW/NW	25.0	62.5	60.0	65.0	0.744
OW/OB	15.0	37.5	40.0	35.0	
Age (yrs)					
20 - 39	12.0	30.0	30.0	30.0	0.524
40 - 44	13.0	32.5	25.0	40.0	
>45	15.0	37.5	45.0	30.0	
Allergy diagnosis					
No	39.0	97.5	95.0	100.0	0.311
Yes	1.0	2.5	5.0	0.0	
Federated athlete					
No	25.0	62.5	80.0	45.0	0.022
Yes	15.0	37.5	20.0	55.0	
Sports experience					
PARL	34.0	85.0	90.0	80.0	0.376
NL	6.0	15.0	10.0	20.0	
Exercise frequency (s/w)					
1 – 3	13.0	32.5	45.0	20.0	0.116
4 – 6	26.0	65.0	50.0	80.0	
≥7	1.0	2.5	5.0	0.0	
Exercise time (h/w)					
1 – 8	12.0	30.0	45.0	15.0	0.115
9 – 10	16.0	40.0	30.0	50.0	

≥11	12.0	30.0	25.0	35.0	
Double training session					
No	28.0	70.0	65.0	75.0	0.490
Yes	12.0	30.0	35.0	25.0	
	n	Mean ±SD	Mean ±SD	Mean ±SD	*p*
Age (yrs)	40.0	45.0 ±11.9	46.4 ±13.9	43.5 ±9.5	0.455
Height (m)	40.0	1.75 ±0.05	1.75 ±0.05	1.74 ±0.05	0.335
Body mass (kg)	40.0	74.1 ±11.7	76.5 ±14.6	71.7 ±7.4	0.199
BMI (kg/m^2)	40.0	24.2 ±3.4	24.7 ±3.9	23.8 ±2.9	0.404
TSM (yrs)	40.0	11.2 ±7.8	11.5 ±7.6	8.5 ±8.0	0.349
Exercise frequency	40.0	4.1 ±1.3	4.0 ±1.6	4.0 ±1.1	0.167
Exercise time (h/w)	40.0	9.4 ±2.6	8.9 ±2.9	9.9 ±2.3	0.214

Abbreviations: BMI, body mass index; LW/NW, low and normal body mass; OW/OB, overweight or obese; PARL, provincial, autonomous or regional level; NL, national level; SD, standard deviation; h/w, hours per week.

Table 2. Nutrition planning and counseling, nutrition timing and gastrointestinal problems of male cyclists sample.

	Overalltool (n=40)		Cycling modality race: Marathon distance (n= 20)	Cycling modality race: Long-distance(n= 20)	*p*
	n	%	%	%	
Special planning	12.0	30.0	10.0	50.0	0.006
Nutrition planning	20.0	50.0	40.0	60.0	0.206
Nutrition counselling					
Coach	2.0	5.0	5.0	5.0	0.834
Internet	3.0	7.5	5.0	10.0	
Nutritionist	1.0	2.5	0.0	5.0	
Friend	2.0	5.0	5.0	5.0	
None	32.0	80.0	85.0	75.0	
Pre-competition intake	39.0	97.5	95.0	100.0	0.311
Intra-competition intake	40.0	100.0	100.0	100.0	-
Post-competition intake	38.0	95.0	90.0	100.0	0.147
GIP during competition					
GIP	9.0	22.5	10.0	35.0	0.058
Burps	2.0	5.0	0.0	10.0	0.147
Bloating	2.0	5.0	0.0	10.0	0.147
Gases	5.0	12.5	5.0	20.0	0.151
Flatulence	1.0	2.5	0.0	5.0	0.311
Stomachache	3.0	7.5	10.0	5.0	0.548
Urge to defecate	3.0	7.5	10.0	5.0	0.548
Mushy stool or diarrhoea	3.0	7.5	10.0	5.0	0.548
	n	Mean ±SD	Mean ±SD	Mean ±SD	*p*
Pre-competition (1 h, g)					

CHO from liquids	23.0	27.3 ±17.6	22.8 ±16.2	31.4 ±18.5	0.249
CHO from semiliquids	8.0	33.7 ±32.9	28.5 ±41.2	22.0 ±4.0	0.177
CHO from solids	26.0	47.6 ±23.2	38.0 ±15.1	57.3 ±26.2	0.030
Intra-competition (g/h)					
CHO from liquids	33.0	18.7 ±12.1	14.4 ±9.1	17.3 ±13.9	0.610
CHO from semiliquids	36.0	19.0 ±15.8	10.5 ±13.0	17.4 ±17.9	0.373
CHO from solids	32.0	10.7 ±6.4	8.9 ±4.4	11.7 ±7.3	0.235
Post-competition (1 h, g)					
CHO from liquids	34.0	35.7 ±26.5	26.1 ±18.3	35.0 ±30.5	0.106
CHO from semiliquids	2.0	21.0 ±1.4	21.0 ±1.4	-	-
CHO from solids	30.0	57.7 ±37.6	48.8 ±41.5	65.6 ±33.2	0.228

Abbreviations: GIP, gastrointestinal problems; CHO carbohydrates

Regarding nutritional advice and planning, GI problems and the type of CHO consumed are shown in Table 2. Half of the participants had a nutrition plan before the competition. Most of the male cyclists did not have nutrition counselling before the competition and had a pre-, intra-, or post-competition intake strategy. Less than a quarter of athletes reported a gastrointestinal problem during competition, such as gases, urge to defecate, stomachache, and mushy stool or diarrhoea were the most common referred symptoms. Pre-, intra- and post-competition CHO intake from solids, liquids or semi-liquids are also shown in table 2.

Findings related to nutritional intake in the 60 minutes prior to competition are displayed in Table 3.

Participation in the long competition was associated with elevated levels of total fluid consumption, ml/kg body mass, total CHO consumption and g CHO/kg body mass. ($p<0.05$). No significant differences were found in the rest of the nutrients analysed. Significant differences were found between groups in the recommended nutrient ranges for the fluids ($p=0.014$). Despite body mass-relative caffeine intake (i.e., relative to body mass, g/kg) was not different between marathon distance and long-distance cyclists ($p=0.509$), it was observed ($d= 0.66$).

The nutritional intakes per hour during the competition are exhibited in Table 4. The long-distance cyclists ingested more fluids (i.e., relative to body mass, ml/kg), protein and fat (i.e., relative to body mass, g/kg), and total or body mass relative energy, carbohydrates and sodium (Table 4, $p<0.050$). The effect size was large for protein and fluids intake ($d= 0.51$ and 0.81, respectively), and medium for fat intake ($d=0.41$, respectively). The effect size was large for protein and fluids intake (d= 0.51 and 0.81, respectively), and medium for fat intake (d=0.41, respectively). The total energy intake showed a large effect size (d=1.17), while body mass relative energy intake showed a trivial effect size (d=0.14). The carbohydrate intake showed a large effect size (d= 1.17 to 2.61). Sodium intake showed a moderate to large effect size (d=0.44 to 0.70).

Table 3. Pre-competition fluids, energy, and nutrient intake of a sample of male cyclists.

	Overall (n=40)		Cycling modality race: Marathon distance (n= 20)	Cycling modality race: Long-distance (n= 20)	*p*	Effect size
Pre-competition intake	**n**	**Mean ±SD**	**Mean ±SD**	**Mean ±SD**		
Fluids (ml)	38.0	550.0 ±292.2	430.0 ±186.1	658.2 ±330.6	0.014	0.85[a]
Fluids (ml/kg)	38.0	7.5 ±4.4	5.6 ±2.5	9.2 ±4.9	0.009	0.93[a]
Energy (kcal)	35.0	375.3 ±227.1	342.0 ±211.7	410.5 ±243.7	0.381	0.30[a]
Energy (kcal/kg)	35.0	5.1 ±3.3	3.2 ±3.1	5.8 ±3.4	0.324	0.23[b]
Carbohydrates (g)	33.0	65.1 ±37.4	53.4 ±34.4	79.1 ±37.1	0.047	0.72[a]
Carbohydrates (g/kg)	33.0	0.90 ±0.54	0.72 ±0.50	1.10 ±0.54	0.044	0.73[a]
Protein (g)	34.0	10.8 ±9.3	11.6 ±11.0	8.5 ±7.0	0.309	0.43[b]
Protein (g/kg)	34.0	0.15 ±0.13	0.12 ±0.15	0.11 ±0.09	0.480	0.12[b]
Fat (g)	33.0	9.4 ±9.0	7.5 ±8.6	7.1 ±9.6	0.815	0.04[b]
Fat (g/kg)	33.0	0.13 ±0.12	0.09 ±0.12	0.09 ±0.13	0.942	0.01[b]
Sodium (mg)	35.0	269.9 ±241.0	211.5 ±257.2	210.7 ±230.4	0.895	0.02[b]
Sodium (mg/kg)	35.0	3.8 ±3.7	2.5 ±4.2	2.8 ±3.2	0.973	0.00[b]
Caffeine (mg)	19.0	108.8 ±76.5	133.7 ±101.8	80.0 ±41.8	0.332	0.22[b]
Caffeine (mg/kg)	19.0	1.4 ±0.9	1.5 ±1.1	1.1 ±0.5	0.509	0.66[a]
	n	%	%	%	*p*	
Fluids						
<5 ml/kg	12.0	31.6	50.0	15.0	0.014	
5 - 7 ml/kg	6.0	15.8	22.2	10.0		
>7 g/kg	20.0	52.6	27.8	75.0		
Carbohydrates						
<1 g/kg	20.0	60.6	72.2	46.7	0.135	
≥1 g/kg	13.0	39.4	27.8	53.3		
Caffeine						
<1 mg/kg	5.0	26.3	37.5	18.2	0.089	
1 - 3 mg/kg	12.0	63.1	37.5	81.8		
>3 mg/kg	2.0	10.5	25.0	0.0		

Note: The effect size was based on Cohen's d[a] or rank-biserial correlation coefficient[b]

Table 4. Intra-competition fluids, energy and nutrient intake per hour of a sample of male cyclists.

	Overall (n=40)		Cycling modality race: Marathon distance (n= 20)	Cycling modality race: Long-distance (n= 20)	*p*	Effect size
	n	Mean ±SD	Mean ±SD	Mean ±SD		
Intra-competition intake						
Fluids (ml/h)	40.0	516.6 ±177.7	525.9 ±193.1	507.4 ±165.8	0.786	0.04[b]
Fluids (ml/kg)	40.0	38.2 ±19.8	22.8 ±7.9	47.8 ±16.1	0.000	0.81[b]
Energy (kcal/h)	40.0	186.2 ±92.3	139.3 ±76.3	233.0 ±84.0	0.000	1.17[a]
Energy (kcal/kg)	40.0	15.4 ±11.7	6.4 ±3.8	24.4 ±9.8	0.000	0.14[a]
Carbohydrates (g/h)	40.0	41.1 ±21.2	30.3 ±17.2	51.9 ±19.6	0.000	1.17[a]
Carbohydrates (g/kg)	40.0	3.4 ±2.5	1.4 ±0.8	5.3 ±2.0	0.000	2.61[a]
Protein (g/h)	36.0	1.7 ±2.0	0.41 ±1.9	1.5 ±2.0	0.091	0.28[b]
Protein (g/kg)	36.0	0.15 ±0.21	0.02 ±0.11	0.15 ±0.26	0.002	0.51[b]
Fat (g/h)	34.0	1.4 ±1.8	0.25 ±1.4	0.96 ±2.1	0.270	0.19[b]
Fat (g/kg)	34.0	0.13 ±0.21	0.01 ±0.08	0.10 ±0.26	0.015	0.41[b]
Sodium (mg/h)	40.0	181.9 ±175.6	74.8 ±134.9	204.0 ±195.4	0.005	0.44[b]
Sodium (mg/kg)	40.0	15.5 ±18.7	3.5 ±5.9	20.3 ±21.8	0.000	0.70[b]
Caffeine (mg/h)	24.0	27.4 ±23.6	37.2 ±37.8	24.2 ±17.0	0.252	0.44[a]
Caffeine (mg/kg)	24.0	2.2 ±1.7	1.7 ±1.6	2.4 ±1.7	0.344	0.46[a]
	n	%	%	%	*p*	
Fluids						
<400 ml/h	12.0	30.0	35.0	25.0	0.702	
400 - 800 ml/h	25.0	62.5	60.0	65.0		
> 800 ml/h	3.0	7.5	5.0	10.0		
Carbohydrates						
<30 g/h	11.0	27.5	40.0	15.0	0.019	
30 - 60 g/h	20.0	50.0	55.0	45.0		
60 - 90 g/h	9.0	22.5	5.0	40.0		
Sodium						
<300 mg/h	34.0	85.0	90.0	80.0	0.517	
300 - 600 mg/h	5.0	12.5	10.0	15.0		
>600 mg/h	1.0	2.5	0.0	5.0		
Caffeine						
0 mg/kg	16.0	40.0	70.0	10.0	0.001	
<1 mg/kg	8.0	20.0	15.0	25.0		
1 - 3 mg/kg	8.0	20.0	5.0	35.0		
>3 mg/kg	8.0	20.0	10.0	30.0		

Note: The effect size was based on Cohen's d[a] or rank-biserial correlation coefficient[b]

Nutritional intakes during the hour following the competition are displayed in Table 5. Despite body mass relative fluids and caffeine post-competition intake was not different between marathon and long-distance (p>0.050), it was observed a moderate effect size (d= 0.62 and 0.72, respectively).

Table 5. Post-competition fluids, energy and nutrient intake of a sample of male cyclists.

	Overall (n=40)		Cycling modality race: Marathon distance (n= 20)	Long-distance (n= 20)	*p*	Effect size
	n	Mean ±SD	Mean ±SD	Mean ±SD		
Post-competition intake						
Fluids (ml)	38.0	933.7 ±416.0	806.0 ±271.7	1,048.5 ±491.6	0.072	0.61[a]
Fluids (ml/kg)	38.0	12.9 ±6.1	11.0 ±4.4	14.7 ±7.1	0.067	0.62[a]
Energy (kcal)	37.0	628.8 ±402.0	543.5 ±322.4	701.4 ±454.5	0.239	0.40[a]
Energy (kcal/kg)	37.0	8.8 ±5.8	4.4 ±5.4	8.7 ±6.1	0.437	0.13[b]
Carbohydrates (g)	37.0	80.7 ±49.0	52.7 ±41.8	86.3 ±52.5	0.175	0.22[b]
Carbohydrates (g/kg)	37.0	1.1 ±0.7	0.75 ±0.74	1.3 ±0.74	0.135	0.24[b]
Protein (g)	36.0	31.4 ±23.8	27.9 ±24.3	34.5 ±23.6	0.411	0.15[b]
Protein (g/kg)	36.0	0.44 ±0.34	0.24 ±0.38	0.48 ±0.31	0.350	0.28[a]
Fat (g)	33.0	13.2 ±12.0	9.8 ±10.1	10.7 ±13.5	0.612	0.09[b]
Fat (g/kg)	33.0	0.18 ±0.17	0.11 ±0.15	0.16 ±0.18	0.638	0.08[b]
Sodium (mg)	36.0	517.3 ±445.8	300.4 ±309.9	590.1 ±523.9	0.117	0.26[b]
Sodium (mg/kg)	36.0	7.2 ±6.4	3.4 ±4.7	8.5 ±7.4	0.132	0.25[b]
Caffeine (mg)	9.0	70.5 ±61.8	33.2 ±27.0	54.8 ±73.4	1.000	0.00[b]
Caffeine (mg/kg)	9.0	0.94 ±0.82	0.60 ±0.27	1.11 ±0.97	0.417	0.72[a]
Carbohydrates/protein	36.0	7.2 ±14.9	2.9 ±21.1	2.7 ±2.8	0.623	0.08[b]
	n	%	%	%	*p*	
Carbohydrates						
<0.8 g/kg	15.0	40.5	58.8	25.0	0.082	
0.8 – 1.2 g/kg	4.0	10.8	11.8	10.0		
>1.2 g/kg	18.0	48.6	29.4	65.0		
Protein						
<0.2 g/kg	10.0	28.6	43.7	15.8	0.170	
0.2 – 0.4g/kg	7.0	20.0	12.5	26.3		
>0.4 g/kg	18.0	51.4	43.7	57.9		

Note: The effect size was based on Cohen's d[a] or rank-biserial correlation coefficient[b]

In consideration of the correlations between the finishing time of the competition and the variables analysed, a positive correlation was identified for the athletes participating in the marathon distance with respect to age (p=0.000), body mass (p=0.007), BMI (p=0.000) and time in the sport modality (p=0-001). Regarding the nutrients analysed, only a negative trend was found between of caffeine per hour intake during the competition and the finishing time (p=0.090), and a negative correlation between the fluids intake (ml/kg body mass) in the following hour and the finishing time (p=0.000).

Regarding the long-distance category, negative correlations were found between the finishing time and the frequency of weekly exercise (p=0.004), the intake of caffeine per hour during the competition (p=0.027) and a strong negative trend with the intake of CHO per hour during the competition (p=0.062). Furthermore, a positive correlation was found between pre-competition fluid intake (ml/kg body mass) and finishing time (p=0.012). Tables containing correlation calculations could be located in the supplementary material section.

DISCUSSION

Food intake, supplements, fluids, and gastrointestinal discomfort experienced in 40 MTB athletes participating in the Gran Fondo Sierra de Alcaraz event, were assessed in this study ,comprised two modalities and two different distances: MTB Long Distance (143 km) and Marathon (64 km). Information was collected using a validated questionnaire, NIQEC questionnaire[16].

In terms of pre-competition time, every group met the recommendations of CHO(1 g/kg) and liquids (5–10 mL/kg or 400–600 mL)[18,19] , similar data to other endurance sports (trail runners and triathletes) was observed by Jiménez-Alfageme et al. [20].

During the competition, the study results showed that cyclists CHO intake was below current recommendations, which suggest that athletes should consume between 90-120 g/h of CHO during events exceeding 2.5 hours, using both SGLT1 and GLUT5 (glucose and fructose) transporters to facilitate absorption.[21,22] This average intake (41.1 g/h) is comparable to, though marginally higher than, that documented for other endurance athletes such as trail runners over various distances in several studies (31 g/h, 35 g/h)[21,23] or marathoners (35 g/h)[24,25]. However, it

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was lower than that reported for middle- and long-distance triathletes in several studies (47 g/h, 62 g/h, 65 g/h, or 71 g/h)[21,25].

Regarding hydration, participants were (average 0,5 mL/h) in the recommended range established by the ACSM (0.4-0.8 L/h) [13], higher intake than that found in studies on trail runners and middle-distance triathletes (447.1 and 422.5 mg/h, respectively) [20]and marathon runners (466 and 354 mL/h)[24,25], but lower than that reported for long-distance triathletes and cyclists (between 643 and 794 mL/h)[25].

Following the hydration data during event, the sodium average consumed by total sample (181.9 mg/h) was considerably below the recommendations for long-duration endurance events (300-600 mg/h), which could increase the risk of hyponatremia, especially in high-temperature conditions[13]. This results were similar to what reported in previous studies on marathon runners (118 and 192 mg/h)[24,25], but lower than in trail runners and middle- and long-distance triathletes (between 269.5 and 444 mg/h)[21,25].

Concerning the post-competition period, no significant differences were observed between nutrition intake of participants in both distances, but CHO intake in the short-distance group did not meet suggested recommendations of 0.8–1 g/kg[26], it seems that this is also observed in other endurance sports such as triathlon and trail running [20].

To conclude the discussion on the nutrient and energy part of the issue, a comparative analysis revealed significant differences in nutritional intake based on competition distance. Long-distance participants (140 km) exhibited significantly higher consumption of kilocalories, CHO, and sodium during competition ($p<0.05$), as well as greater fluid and CHO intake in the pre-competition period. These results were similar to the study by Martinez et al. [23] which documented similar patterns in mountain ultramarathon runners, identifying a direct relationship between competitive distance and CHO intake. This convergence of findings across different endurance disciplines reinforces the hypothesis of a natural adaptation of nutritional strategies according to effort duration, possibly as a compensatory mechanism for greater glycogen depletion in prolonged events[21].

In addition to dietary intake data, the study analysed possible gastrointestinal complaints perceived by the participants, and results of less than 25% were lower than compared to other endurance events, where rates could range between 30% and 90% of participants according to various studies [27] . Paradoxically, the relatively low CHO intake observed in this study (41.1 g/h) could partially explain the lower prevalence of digestive problems, albeit at the cost of potentially suboptimal performance. These findings align with Pfeiffer et al.'s 2012 study[25] which found a positive correlation between CHO intake and the incidence of gastrointestinal problems in endurance athletes, demonstrating that intakes exceeding 60 g/h were associated with higher rates of gastrointestinal distress.

As regards ergogenic aids a key finding of the study was the negative correlation between caffeine consumption and finishing time in both distances, suggesting an ergogenic effect of this compound. This is consistent with the ISSN Position Stand[14] and a 2022 meta-analysis[28] which state that caffeine's effects are particularly relevant in disciplines such as MTB, concluding that caffeine could improve endurance performance by 1.1% to 2.7%, a margin considered relevant in elite competitions.

Finally, some aspects related to performance were analysed. On the one handa not statistical significance negative correlation (p=0.062) was also identified between CHO intake per hour and finishing time in the long-distance event, but even not statistical significance they were consistent with various endurance sports studies[25,29] which observed performance improvements associated with higher CHO intake during prolonged exercise. On the other hand, Different performance predictors were also identified based on race distance. In the Marathon modality (62 km), anthropometric factors (body mass, BMI) and age showed significant positive correlations with finishing time, while in the long-distance category, weekly exercise frequency emerged as a negative predictive variable. This dichotomy has been supported by Allen and Hopkins' research[30] which established that in shorter events, body composition has greater influence, whereas metabolic efficiency parameters become more relevant in ultra-endurance competitions.

On another note, a concerning finding of the study was that only half of the participants had an established nutritional plan for the day prior to competition, and most did not receive specialized nutritional advice. Similar trends have been reported in other endurance sports, such as marathon running, where a higher percentage of pre-competition nutritional planning was observed, yet the lack of professional guidance persisted. This absence of tailored nutritional support and planning may partly explain the suboptimal CHO and sodium intake recorded during the race, leading to conclusions similar to those of Burke et al. (2017)[18], who found that personalized nutritional interventions significantly enhance performance.

Limitations

The use of the NIQEC instrument in this study responds to the need for systematic tools that allow for the structured and formative collection of nutritional intake data in competitive contexts, without the intention of measuring latent constructs or psychological dimensions. It is a descriptive-type questionnaire, in which each item has individual, non-aggregable informational value referred to as formative indicators, as opposed to reflective or latent indicators[31]. In such instruments, internal consistency measures and factor analyses are not appropriate, as the items are not required to correlate with each other in order to be considered valid[32]. Although the questionnaire was developed through a Delphi process involving expert judgement, formal indices of content validity such as the Content Validity Index (CVI) were not calculated, which constitutes a relevant methodological limitation[33]. Similarly, the absence of inter-rater reliability analyses, such as the Kappa coefficient or the Intraclass Correlation Coefficient (ICC), prevents confirmation of the instrument's stability across different observers. In order to provide support for the instrument's validity, cognitive interviews were conducted with athletes during the NIQEC development process[17]. The purpose of these interviews was to assess the comprehensibility and feasibility of the questionnaire, including the clarity of items and instructions, the response format, and example answers.

The observational and cross-sectional design prevents the establishment of causality between variables. The sample size of 40 male cyclists limits generalization to female athletes and other endurance profiles. Due to the nature of convenience sampling, the study was underpowered, where a participation of 19% of the cyclists who completed the competition was obtained. In addition, self-reported post-event data could introduce recall bias, which can lead to errors in the quantity and type of information reported (food, supplements, fluids, or gastrointestinal problems). However, the questionnaire used was developed for content, applicability, structure, and presentation, unlike other studies where unvalidated or non-consensual questionnaires were employed. Additionally, endurance athletes tend to be highly concerned about their diet and training, as their performance depends on it, making them more likely to accurately recall their intake compared to the general population.

The psychometric validation of the NIQEC instrument represents another limitation. As it is a formative questionnaire with a descriptive nature, it is not appropriate to assess its internal consistency using Cronbach's alpha or to conduct structural validity analyses, since the items do not reflect a unifying construct[31]. On the other hand, although the development of the questionnaire was based on expert consensus through a Delphi process, no quantitative indices of content validity, such as the Content Validity Index (CVI), were calculated[33], which limits the empirical evidence supporting its validity. Taken together, these aspects should be addressed in future stages of the instrument's development in order to consolidate its reliability and validity for use in clinical and sports practice.

Strengths

The study employed the NIQEC questionnaire, which has been specifically validated for endurance competitions. Although the sample size calculation was performed to ensure adequate statistical power for the primary outcome, the final sample was determined by the number of athletes who voluntarily completed the questionnaire during the competitions. As such, the study reflects a convenience sample with sufficient statistical power, but future studies should consider broader recruitment strategies to enhance representativeness and generalisability. Nutritional assessments at three time points (pre-, during, and post-competition) provide a comprehensive overview, and comparing distances enables specific adaptations according to competitive demands to be identified.

CONCLUSIONS

The present study observed that CHO and sodium intake were below the recommended levels for endurance events of this nature. However, fluid consumption met the established guidelines.

The results revealed that only 50% of participants had a structured nutritional plan, and the majority did not receive specialised nutritional counselling.

A negative correlation was identified between caffeine intake and finishing time, and a trend towards a negative correlation in the long-distance group between CHO intake during the competition and finishing time.

These findings highlight the need to improve nutritional planning. Optimising CHO and sodium intake in mountain cyclists is essential, with gastrointestinal tract training emerging as a recommended strategy. Nutritional strategies should be adapted according to the competitive distance.

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AUTHOR CONTRIBUTIONS

MCM: methodology, formal analysis, visualization, writing—original draft preparation; RJ-A: Conceptualization, methodology, visualization, writing—original draft preparation; CIA-G: methodology, data curation, formal analysis, writing—original draft preparation; SMH: data curation, formal analysis, writing—original draft preparation; IS: Conceptualization, methodology, visualization, project administration, writing—review and editing; AN: methodology, data curation, visualization, writing—review and editing; DR-G: data curation, formal analysis, writing—original draft preparation; LH-P: data curation, formal analysis, writing—original draft preparation; JMMS: Conceptualization, methodology, visualization, project administration, writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY

Data from this study are available upon request from the corresponding author. Raw data is available via the following link: https://doi.org/10.5281/zenodo.15825477

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the ethics committee of the University of Alicante with the file number UA-2022-02-01 and followed the World Medical Association codes and Declaration of Helsinki for research in humans.

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