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Habitual Dietary Intake among Recreational Ultra-Marathon Runners: Role of Macronutrients on Performance

Sara E. Mahoney*, Andrew D. Carnes, Thomas R. Wójcicki, Emily Frith, Kaitlin Ferry

Department of Exercise Science, Bellarmine University, Louisville, KY 40205, USA
*Corresponding author: smahoney@bellarmine.edu

Abstract Ultra-marathons (footraces greater than 42.2 km) are increasing in popularity, however little is known about the habitual dietary intake of these runners. The aim of this investigation was to empirically describe the habitual training diet of ultra-marathon runners and determine if macronutrient intake was associated with 161-km race performance. To assess habitual diet, runners recruited from five 161-km ultra-marathons across the U.S. (N = 47) completed a diet and training questionnaire, and a web-based 24-hour dietary recall on three separate days within 1-4 weeks prior to a 161-km race. Multiple linear regression was used to predict finish time with covariates carbohydrate, fat and protein, expressed relative to body weight ($g \cdot kg^{-1}$) and total intake (% of diet). To determine differences in macronutrient intake between finishers and non-finishers, two-sample t-tests were used. Dietary intake was varied among participants; mean carbohydrate intake (5.19±2.62 $g \cdot kg^{-1}$), fat (36.48±10.42%) and protein (1.86±0.67 $g \cdot kg^{-1}$). Macronutrient intake ($g \cdot kg^{-1}$) predicted finish time (R^2 = 0.232, P =0.036), however fat was the only significant covariate (t = -2.90, P =0.007). Relative macronutrient intake (% of diet) did not predict finish time (R^2 =0.145, P =0.155). No significant differences were found in macronutrient intake between finishers (n=36) and non-finishers (n=11). Habitual dietary fat intake in ultra-marathon runners was a significant predictor of 161-km finish time, regardless of carbohydrate or protein intake. Further investigation is warranted to determine the optimal nutrient intake in ultra-marathon runners to maximize performance.

Keywords: *sport nutrition, ultra-endurance, endurance performance*

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1. Introduction

Participation in ultra-marathon races has recently experienced a substantial surge in popularity [1,2]. While any race longer than a traditional marathon (42.2 km) can be considered an ultra-marathon, emerging research has focused attention on 161-km (100 mile) races [3]. Due to the extreme metabolic demand of such events [4], maintaining fuel availability is a crucial component of ultra-marathon performance [5]. Ample research has established that carbohydrate (carbohydrate) serves as the principal fuel source during continuous exercise at >65% VO2 max (maximal aerobic capacity), and depletion of carbohydrate is implicated in fatigue [6,7]. Current nutritional recommendations for endurance athletes therefore emphasize high dietary intake of carbohydrate during training and prior to competition to maximize muscle glycogen stores [8]. An individual approach for carbohydrate consumption is also recommended: for athletes training approximately 1 hour per day, 5-7 g•kg-1, 6-10 g•kg-1 for training 1-3 hours at a moderate to high intensity, and 8-12 g•kg-1 for those with "extreme commitment" of ≥4-5 hours per day [9]. However, ultra-endurance events are performed at significantly lower intensity than traditional endurance events such as the marathon at which lipid sources, rather than carbohydrate, would provide the majority of energy [4,10].

Without access to professional nutrition advice, recreational runners may utilize anecdotal evidence and rely on popular media to deliver nutrition information and recommendations. In the past several years, winners of major 161-km races have reported the use of low-carbohydrate diets, high fat diets (LCHF), and thus, interest in these diets may be increasing among recreational ultra-endurance athletes [11,12]. The use of LCHF diets to improve endurance performance have been largely unsuccessful in traditional endurance athletes [13], primarily due to the reduction in carbohydrate oxidation during exercise [13,14,15]. While LCHF diets have been ineffective at improving traditional endurance performance, there is growing interest in the use of this diet among ultra-endurance athletes [16], as the relative competition intensity is significantly lower than endurance events (marathon distance and below). To date, evidence of a beneficial performance effect for low carbohydrate intake in ultra-endurance is minimal [17,18], and therefore is not currently recommended.

Given the variety of messages ultra-marathon runners may receive regarding optimal nutrition, it is important to describe their habitual dietary intake and determine its relationship to ultra-marathon performance. While research is emerging in this area [19], current studies primarily investigate the role of dietary intake during competition, rather than the impact of habitual training diet [20,21,22,23,24]. Therefore, the aim of this investigation was to 1) describe the habitual training diet of ultra-marathon runners both empirically through dietary recall and subjectively via participants' self-perception and 2) determine if habitual macronutrient intake was associated with 161-km finish time. We hypothesized that macronutrient intake would be varied among participant, and those who consumed high carbohydrate diets would have faster finish times.

2. Methods

Participants from five 161-km ultra-marathons across the contiguous United States (i.e., Mohican 100, Loudenville, OH; Rocky Raccoon 100, Huntsville, TX; Brazos Bend 100, Needville TX; Wildcat 100, Pensacola, FL; Pistol Ultra Run, Alcoa, TN) were recruited to the RUN100 Study via email, following permission from the race directors who were contacted by research staff via email. This descriptive study was approved through the Human Subjects Review Board and informed consent was obtained prior to data collection.

Participants were contacted 4-6 weeks prior to their race date, and were required to complete a web-based dietary recall and battery of questionnaires at least seven days prior to the race. The survey battery was delivered through SurveyMonkey, Inc. (Palo Alto, CA), and the dietary recall was completed through the online Automated Self-Administered 24-hour Recall [25]. In total, 70 participants were recruited and completed the informed consent, however only 47 completed all study assessments.

2.1. Survey Battery

The survey battery included a general demographic and health history questionnaire and a training and diet survey. Regarding diet, participants were asked to self-identify their dietary habits in two single-item responses: 1)"How would you describe your current diet?" Select from: Traditional American (approximately 50% carbohydrate, 15% protein, 35% fat), Vegan (no animal products), Vegetarian (no meat), Paleo (based on Paleolithic eating patterns which are typically high in meat and vegetables, and restrict grains and dairy), Other, or None. 2)"How would you categorize your carbohydrate intake?" (i.e. High Carbohydrate, Low Carbohydrate or None). Self-identification of dietary intake was used in this sample of recreational runners to determine intended dietary intake, as none of the participants are professional athletes and may not have access to professional nutritional advice. Therefore, this measure was used to compare the participants' perception of intake against the actual macronutrient composition of habitual diet. Regarding training, participants recorded total number of miles run during the week of dietary recall to compare dietary intake to training load, and reported previous ultra-marathon personal records for the 161-km or 80.5km distance as applicable to compare the relative ability of participants.

2.2. Dietary Recall

Three-day, 24-hour recalls were used to capture habitual training diet, which has been used previously in a similar population [19,26,28]. While professional and elite athletes typically periodize their dietary intake to match training load, recreational may athletes lack this sophistication. In fact, in this sample, 21.2% of participants did not follow any particular diet. Habitual dietary intake for participants was assessed using the Automated Self-Administered 24-hour Recall [ASA24; 25], which is a web-based dietary recall program that guides participants through a detailed recording of their daily dietary and fluid intake. Participants reported intake on three self-selected, non-consecutive days, including two weekdays and one weekend day, all occurring at least seven days prior to the race to capture habitual patterns. Each entry was open for 72 hours and was subsequently locked after the time elapsed. ASA24 software was used to calculate total kilocalorie and macronutrient (carbohydrate, fat, and protein) intake.

2.3. Race Completion and Performance

Performance data was obtained through the race director, via online results. For those who completed the race, time to completion in hours, minutes, and seconds was recorded, and DNF (did not finish) was recorded for those who did not complete the race, regardless of drop out distance.

2.4. Data Analysis

Multivariate linear regression analysis (IBM SPSS Statistics, Version 22.0; IBM Corp., Armonk, NY) was used to determine the relationship between macronutrient intake (carbohydrate, protein, and fat) and race performance (measured as finish time). Additionally, Pearson product moment correlation analysis was completed to determine the relationship between macronutrient intake and finish time. Comparisons in macronutrient intake between finishers and non-finishers were made using a two sample t-test. One-way ANOVAs were used to determine if a difference existed in weekly training volume or 80.5km personal best time among the dietary intake groups reported in Survey Question 1. Non-paired t-tests were used to determine if a difference existed in either of these variables between dietary groups reported in Survey Question 2.

3. Results

3.1. Demographics

Participants (n =47) were middle aged (mean age 43.4±9.7 years), predominantly male (63.8%) and reported a healthy BMI (24.4±4.6 kg•m-2). Demographic data were similar between genders; however men had a significantly higher BMI than women (Table 1).

3.2. Typical Dietary Intake

Dietary intake was varied among participants (Table 2). Overall, runners consumed near the low end of recommendations for endurance athletes' carbohydrate intake (5.19±2.62 g•kg-1•day-1), however, they exceeded the recommendations for protein intake (1.86±0.67 g•kg-1•day-1) and fat intake (36.48±10.38 % diet; Rodriguez et al., 2009; Burke et al., 2011).

Table. 1. Demographic data from 47 participants

	Male (n=30)	Female (n=17)	P-value
Age	43.5±10.4	43.5±9.4	>0.05
BMI	25.02±3.6	*21.6±2.2	0.01
Ethnicity	90% White, non-Hispanic	82.5% White, non-Hispanic	
Presence of co-morbidity	Asthma (n=6), Hypertension (n=3), Hyperlipidemia (n=1)	Asthma (n=2), COPD (n=1)	
Marital status	90% Married/partnered	82.5% Married/partnered	
Employment	96.6% working full time	76.4% working full time	
Education	100% college educated	94.1% college educated	

Data presented as mean ±SD
BMI = Body mass index.

Table 2. Habitual macronutrient intake for ultra-marathon runners

Macronutrient Intake	Carbohydrate	Fat	Protein
$g \cdot day^{-1}$	351.78±181.8	128.89±89.69	128.35±53.12
$g \cdot kg^{-1} \cdot day^{-1}$	5.19±2.62	1.85±1.11	1.86±0.67
% of total intake	46.63±13.11	36.48±10.38	17.38±5.43
Recommendations for endurance athletes	5-10 $g \cdot kg^{-1}$	20-35% total diet	1.2-1.4 $g \cdot kg^{-1}$

Data presented as mean ±SD.

3.3. Diet and Training Survey

When completing the dietary recall, participants were asked to categorize their diet; first, as traditional American, vegan, vegetarian, Paleo, other, or none, and then in a separate question as high carbohydrate, low carbohydrate, or no response. 21.2% identified as traditional American diet (n=10), 34.0% identified as vegetarian or vegan (combined due to small sample size, n=16), 14.9% identified as Paleo (n=7), and 29.7% identified as other/none (n=14). Separately, 14.9% identified having a high carbohydrate diet (n=7), 21.2% identified as having a low carbohydrate diet (n=10), and 63.8% reported neither high nor low carbohydrate (n=30, Table 3).

Table 3. Comparison of habitual dietary intake between self-identified diets

Self-Identified Diet Type	Carbohydrate ($g \cdot kg^{-1}$)	Fat ($g \cdot kg^{-1}$)	Protein ($g \cdot kg^{-1}$)	DNF Rate	Mean Finish Time (hours)	80.5km PR (hours)	Weekly training volume ($km \cdot week^{-1}$)
Traditional American (n=10)	4.89±2.91	1.65±1.23	1.72±1.04	1/10 *(10%)*	27.03±2.82	11.02±1.73	84.41±18.27
Vegetarian/Vegan (n=16)	5.93±3.18	1.51±0.66	1.61±0.57	4/16 *(25%)*	26.16±5.26	10.19±1.68	80.10±22.50
Paleo (n=7)	2.46±1.25	1.74±0.75	2.11±.059	4/7 *(57.1%)*	24.75±2.98	11.28±3.69	85.56±34.96
Other/None (n=14)	5.65±2.81	2.28±1.77	2.00±0.65	3/14 (21.4%)	24.96±5.84	10.11±2.26	87.51±33.58
Self-Identified Carbohydrate Intake							
High Carbohydrate (n=7)	5.72±2.49	1.63±1.04	1.92±0.82	0/7 *(0%)*	28.87±0.97	9.96±2.68	93.64±34.24
Low Carbohydrate (n=10)	2.61±1.23	1.88±0.79	2.06±0.56	5/10 *(50%)*	22.89±4.96*	10.53±2.32	82.88±23.42

Data presented as mean ±SD
DNF= Did not finish
PR = personal record.

During the week of dietary recall, runners completed 86.41± 25.23 km, and reported a mean 80.5 km personal record of 10.48, s = 2.11 hours. Participants' 161 km personal record was not reported due to low response rate. No significant differences were found among dietary intake groups for weekly mileage or 80.5 km personal record.

3.4. Race Completion and Performance

Of the 47 participants, 11 (23.4%) did not finish (DNF). From question 1, the lowest DNF rate occurred in the Traditional American diet group (10%) and the highest occurred in the Paleo group (57.1%). From question 2, no participants who self-identified as "high carbohydrate" failed to finish (DNF), whereas the low carbohydrate group had 50% DNF. Mean finish time was 25.88±4.6 hours (Table 3) and the low carbohydrate group (22.89±4.96 hours) finished significantly faster than the high carbohydrate group (28.87±0.97 hours, P =0.01). No significant difference was found between finishers' and non-finishers' carbohydrate, protein, or fat intake.

Relative macronutrient intake ($g \cdot kg^{-1}$, Model 1) was a significant predictor of finish time (R2= 0.232, P = 0.036). However, fat ($g \cdot kg^{-1}$) was the only predictor to reach significance (t = -2.90, P = 0.007). In post-hoc analysis, fat (g•kg-1) was associated with finish time (r = -0.383, p= 0.010), whereas carbohydrate and protein (g•kg-1) were not. Macronutrient intake as a percentage of total diet (Model 2) was not predictive of finish time (R^2 =0.145, P =0.155).

4. Discussion

The purpose of this investigation was to describe the habitual training diet of ultra-marathon runners and to determine if dietary intake was associated with 161-km race performance. Overall, this sample of recreational runners had a varied training diet, consuming near the low end of dietary carbohydrate recommendations for traditional endurance athletes, while exceeding those for protein and fat. Additionally, while dietary carbohydrate and protein intake were not associated with performance, these findings demonstrate that habitual fat intake relative to body weight was predictive of 161-km finish time.

To date, dietary recommendations for endurance athletes from the American College of Sports Medicine, Dieticians of Canada and the American Dietetic Association (ADA et al., 2009) have consistently emphasized a high carbohydrate diet. Other researchers confirm this recommendation, especially for ultra-endurance athletes [9,27]. Interestingly, few runners in this sample self-identified as consuming a high carbohydrate diet (14.5%), and a significant portion of the runners reported consuming a low carbohydrate diet (21.2%), which is contrary to current recommendations. Although some have postulated the benefits of a low carbohydrate, high fat diet [16,17], little empirical evidence exists for the effectiveness of this type of diet for ultra-endurance athletes [13,18,28], and it may be possible that runners are adopting this diet based on anecdotal evidence.

Additionally, those who self-identified as following a high carbohydrate diet only consumed 5.72±2.49 g•kg-1•day-1, which, depending on daily training volume, may not be considered adequate [9]. This demonstrates a clear disparity between runners' perceived intake and actual consumption.

Of interest is the DNF rate and finish time between the self-selected low and high carbohydrate groups. While 7 out of 7 self-identified "high-carbohydrate" runners completed the race, only 5 out of 10 "low carbohydrate" runners finished. Conversely, the mean finish time for the "low carbohydrate" group was significantly faster than the "high carbohydrate" group, noting that there was not a significant difference in training volume or 80.5 km personal record between the two groups. While competitive athletes' aim is to run as fast as possible, many recreational ultra-marathon runners' primary aim is race completion. Further research is therefore warranted to investigate this discrepancy in performance between the two dietary groups.

In regard to race performance, we found that habitual macronutrient intake explained 23.2% of the variance in finish time. Because race performance may be impacted by a variety of factors including training status, motivation, injury, and environmental factors [2], demonstrating the role of habitual diet is particularly important. While the role of intake during an ultra-marathon has been previously described [20,21,22,23,29], this investigation confirms the impact of training diet on performance. When examining the role of individual macronutrients, only fat was a significant predictor of finish time; those with higher habitual fat intake (g•kg-1) finished faster. We interpret this finding with caution, especially as relative macronutrient contribution (% of diet) did not predict race performance; neither a high fat diet nor a high carbohydrate diet predicted faster times. According to our analysis, total fat intake is more important than its relative contribution to total diet. Meaning, a carbohydrate restrictive diet was not necessary to achieve the benefit of increased fat intake. One possible mechanism for this finding is the high total caloric consumption for those with high fat intake, as fat is the most calorie dense (9 kcals•g-1). Due to the high training volume of these runners (mean 84.68, s =24.43 km•week-1), it is possible that many of them do not meet their caloric needs if fat consumption is low. However, it is not yet clear that a high fat diet should be recommended for ultra-endurance athletes.

This study is not without limitation. First, because the data are descriptive, causal inference cannot be made. Additionally, while the ASA24 is a valid and reliable tool for assessing 24 hour recall [25], self-reported dietary recall may underestimate true intake, and therefore caloric intake may be higher than reported. Finally, due to small sample size in self-selected dietary groups, additional research is needed to investigate the relationship between habitual fat intake, finish time, and completion rate, utilizing a randomized controlled design. Also, as clear discrepancies exist between recommendations and runners' intake, future research should investigate primary sources of nutrition information for recreational athletes and common nutrition beliefs.

4.1. Conclusions

Habitual dietary intake among ultra-marathon runners is varied and a considerable percentage of runners follow a low-carbohydrate even in the absence of empirical evidence. We are the first to demonstrate that habitual macronutrient intake, specifically fat intake (g•kg-1•day-1), is predictive of 161-km race performance. While experimental studies are needed to confirm this relationship, these data suggest that ultra-marathon runners who consume higher dietary fat are able to complete a 161-km race faster than those with lower intake.

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Statement of Competing Interest

The authors have no competing interest.

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