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An Analysis of the Nutritional Practices of Club Level Cyclists before and during a Cyclocross Race

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Abstract This study investigated the pre- and during-race dietary intake of club-level cyclocross cyclist and its effects on performance. Ten male cyclists (age: 42 s=4 years, stature: 1.78 s=0.08m, mass: 73.2 s=9.3 kg) took part in this dietary survey and completed a 3-day food and training diary in the days leading up to a field-based cyclocross race. Finishing time was used to measure performance. Mean energy intake (EI), energy expenditure (EE), energy balance and macronutrient intake was calculated for each day. These variables were each compared between days using repeated measures ANOVA with post-hoc Bonferroni adjustment. Pearson correlation was used to identify any relationships between performance and macronutrient intake. Paired samples t-tests were used to compare EI and EE and statistical significance was set at $P \leq 0.05$. EI was significantly greater 1 day before the race than EE ($P=0.031$), while EI was significantly lower than EE on race day ($P=0.000$). Mean carbohydrate (CHO) intake during the 3 days before the race was 5.1 s=1.7 $g.kg^{-1}$BM and at the lower limit of the recommendations of 5-7 $g.kg^{-1}$BM for endurance athletes. Pearson correlation revealed a strong negative relationship between average CHO intake ($g.kg^{-1}$BM) before the event and race time ($r=-0.821$; $P=0.024$). The results would suggest that there is a lack of nutritional strategy amongst cyclist and that behaviour and nutritional knowledge are not very well correlated. Thus, the nutritional knowledge of sub-elite athletes must be developed.

Keywords Cyclocross, Carbohydrates, Nutritional Practices, Energy Intake, Cycling, Nutrition

1. Introduction

Cyclo cross is an outdoor winter sport consisting of a closed circuit that is 2.5-3.5km long and includes rough terrain, forest paths, steep, muddy hills and man-made obstacles[7]which often force cyclists to dismount their cycles and run up hills whilst carrying their bikes on their shoulder[6; 7]. Cyclocross events last approximately 1 hour and are performed at intensities of around 80% of maximum oxygen uptake (VO_{2max})[20]. The intermittent nature of this sport requires the use of both aerobic and anaerobic energy systems where the main fuel is carbohydrate (CHO)[29; 22]. Therefore a high carbohydrate diet which meets daily calorie expenditure is important.

The role of carbohydrates is energy production for daily activities and it is also the preferred fuel for high intensity exercise[21]. The daily CHO requirement of athletes training 7-12 hours per week is 5-7 g.kgBM/day, which provides adequate amount of CHO for training and the re-synthesis of glycogen levels[12]. When large energy deficits incurred during intense training are not compensated for by adequate CHO intake, or accumulate over a number of days the athlete can be faced with excessive fatigue and reduced training response[8]. Although the effects of CHO intake on exercise lasting approximately 1 hour have been investigated extensively, there are currently no research papers that examine the effect of CHO on cyclocross performance. Research on the voluntary food intake of non-elite endurance athletes is also limited, although the current published research has found that macronutrient intake was insufficient[9; 23; 18].

The dietary patterns and knowledge of recreational triathletes were examined by[31]. Despite the large volumes of training reported, food diaries revealed lower than recommended CHO intake (<55%), while protein and fat intakes were met and sometimes exceeded. Reference[18] investigated the pre-competition eating habits of endurance cyclists. The results showed that sub-elite athletes achieved suboptimal CHO intakes even though they indicated CHO-loading practices. In addition, the correlation that was found between pre-competition CHO intake and performance was lost when athlete ability was taken into consideration[18]. These results suggest that although sub-elite athletes are aware of nutritional strategies, their knowledge is inadequate and there are some misconceptions with regards to amount and type of food consumed. This is further confirmed by a qualitative study of[24] who found that nutritional awareness related to the athletes' level of competitiveness; that is the more elite the athletes were, the

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more nutritional knowledge they had. Often the information is derived from newspapers and magazines[31] or based on word of mouth or trial and error[24]. In addition, reference [9] suggested that athletes may not realise their own nutritional needs, especially when trying to lose weight during heavy training periods or lack knowledge, skills and time to meet their nutritional needs for optimal performance. There is also misunderstanding regarding macronutrient intakes, as athletes often follow guidelines for the general population rather than those specific to their sport, and in the old format of percentage of total energy intake rather than the more accurate body weight normalised format[12]. Nevertheless, it seems that scientific information is not translated adequately for those, who haven't got the support of sport nutritionist.

In cycling low body fat levels and leanness are considered an advantage and cyclists often restrict their energy intakes to achieve these targets[11; 22]. However, sustaining these restrained diets for longer periods can compromise training induced adaptations, muscle glycogen re-synthesis, immune function and can lead to loss of lean mass, deficiencies in micronutrients and ultimately, impaired performance[3; 10; 22; 28]. The composition of the athletes' diet is just as important as meeting energy requirements. The literature recommends a diet high in CHO (>70%) and lower in fat intakes (20-25%)[30]. However, expressing macronutrient intake as a percentage of total energy intake does not necessarily mean that athletes meet their energy and macronutrient requirements and that the use of a body weight normalised values are not only more accurate, but also account for differences in body size amongst athletes[13; 22].

To date only one article has been published that examined the eating habits of mountain bike cyclists[26]. However, this study lacked depth in its methodology and there was no effort made to thoroughly investigate energy intake, energy expenditure and macronutrient intake of these athletes. Therefore, the aim of this study was to investigate the pre- and during–race dietary intake of club level cyclocross cyclists and its effects on performance. The secondary aim was to establish if these athletes practice any pre-competition nutritional strategies.

2. Method

2.1. Participants

Participants who registered to take part in Round 13 of the 2011-12 London/South-East Cyclo-Cross League at Dartford, England were recruited at the Herne Hill Velodrome, London (Round 12 of the London/South-East Cyclo-Cross League). Twelve endurance-trained male cyclists volunteered to participate in this dietary investigation. The inclusion criteria specified a minimum of 4 hours of training per week. Two participants were excluded from the data analysis; one as his training diary revealed that he did not meet this inclusion criterion and the other as his food diary analysis had a Physical Activity Level (PAL) of less than 1.35[17].

The characteristics of the remaining 10 participants were age: 42 s=5 years, stature: 1.78 s=0.07 m, mass: 73.1 s=8.8 kg, body fat (BF): 10.3 s=3.0%.

The study was approved by the University Research Ethics Committee. Allparticipants were informed of the nature of the study and written informed consent was obtained prior to the commencement of the study.

2.2. Procedure

Participants were required to complete a 3-day food and training diary in the days leading up to the event. Written instructions were based on the study of[18]. Cyclists were given the opportunity to ask questions if they needed clarification on data recordings.Three days before the race, participants were required to record all drinks and food consumed and report on the nature of the product. On the day of the race, participants were required to record their food intake up to the start of the race, and immediately after the race, to recall any food or drinks consumed during the race using the same method as described above. Cyclists were also asked to specify if they had a pre-race nutritional strategy and indicate what source of information the strategy was based on. In order to ensure accuracy, all information had to be submitted to the principal investigator within 24 hours of the race. Official race times were supplied by the race organiser.

2.3. Body Composition Analysis

On the morning of the race, participants were instructed to empty their bladder and report to be weighed near the sign on desk. Cyclists' height was recorded using a mechanical stadiometer (Seca, Birmingham, UK) and body fat analysis was carried out using a leg-to-leg bioelectrical impedance analyser (Tanita Body Composition Analyser TBF-310, Tanita UK Ltd, Middlesex, UK). For the purpose of body composition analysis, all cyclists described themselves as athletic. Measurements were carried out bare foot and body weight was adjusted by 0.2kg to account for clothing worn.

2.4. Calculation of Energy Intake

Food diaries were analysed using DietPlan 6 Nutritional Analysis Software (Forestfield Software Ltd, UK) to establish energy and macronutrient intake. Items that were not included in the software's database were built up from ingredients or substituted by a suitable alternative. All food diaries were processed by the same researcher and subjects were contacted when items in the food diaries needed clarification. Macronutrient intake was calculated as percentage of daily dietary intake and was also normalised for body weight.

All participants were checked for underreporting using the Goldberg cut-off (Goldberg & Black, 1998). PAL were calculated by dividing the mean reported energy intake over the 3 day period preceding the race by the subjects' estimated Basal Metabolic Rate (BMR) (PAL=EI_{rep}: BMR). According to reference[17], a PAL value that is < 1.35 cannot represent the habitual intake of a free-living active individual and thus, this value was used to identify under-reporting in the current study.

2.5. Calculation of Energy Expenditure (EE)

Resting metabolic rate (RMR) was calculated according to Harris & Benedict (1919). EE due to physical activity and total daily EE were estimated using reference[1; 2]. The current study assumed that apart from energy expended during training, each participant had a relatively similar EE throughout the day and in the period prior to the start of reporting. Therefore, there was no difference made between non-training activities.

2.6. Data Analysis

All data are presented in means and standard deviation. Statistical analysis was carried out using SPSS for Windows 18.0 software (SPSS Inc., Chicago, IL, USA). All data was checked for normality using the Kolmogorov-Smirnov test. One factor repeated measures ANOVA was carried out with post-hoc Bonferroni adjustment to compare energy intake, energy expenditure, energy balance and macronutrient intake between days. Spearman correlation was performed to identify if there was a relationship between finishing position and race day CHO, protein or fat intake. Paired samples t-tests were carried out between energy intake and energy expenditure. Spearman correlation was carried out to identify if there was a relationship between race day energy balance and finishing position. Significance was recognised when $P \leq 0.05$.

3. Results

3.1. Energy Intake

Mean energy and macronutrient intakes for the 3 days prior to the event and for race day are summarised in Tables 1 and 2. Self-reported energy intake increased on each of the three days prior to the race. However, these increases were insignificant ($F_{(2,18)}$=0.374; P=0.693). On the other hand, EE declined from 3D to one day (1D) before the race but these differences were non-significant($F_{(2,18)}$=1.123; P=0.347).

Table 1. Mean Energy Intake on the Days before the Race and on Race Day (n-10), M ± s, Range

	kcal			
Days	**Energy Intake**		**Energy Expenditure**	
3 days	2963.5 s=515.2	2442-3848	2942 s=570.3	2190.3-4122.4
2 days	3070.7 s=470.1	2479-4040	2870.6 s=557.8	2108.3-4190.6
1 day	3184.6 s=508.4	2214-3863	2537.1 s=646.9	1768.5-3431.5
Race Day	914.2 s=366.5	542-1679	1823.2 s=171.5	1589.4-2095.0

3.2. Energy Balance

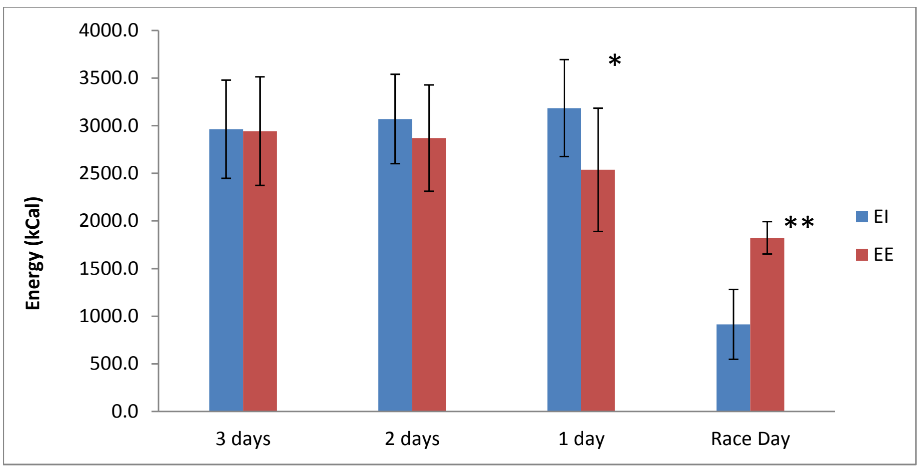

Figure 1. Mean±s for Energy Intake (EI) and Energy Expenditure (EE) (kcal)* Significant differece when P<0.05.**Significant difference when P<0.01

Figure 1 shows energy intake relative to energy expenditure for all 4 days. EI was significantly greater ($t_{(9)}$=-2.564; P=0.031) 1D before the race than EE (3184.6; s=508.4 kcal and 2537.0; s=646.9, respectively). Race day energy intake was significantly lower (914.2; s=366.46 kcal) than race day energy expenditure (1823.2; s=170.56 kcal); ($t_{(9)}$=7.211; P=0.00). Cyclists were found to be in positive energy balance in all 3 days before the race with mean results showing an increase in energy surplus from 3D to 1D before the race. Energy balance was 20.9; s=527.15, 200.2; s=754.7 and 647.6; s=798.8 kcal for 3D, 2D and 1D before the race, respectively. However, these differences were found to be non-significant ($F_{(2,18)}$=1.642; P=0.221).

3.3. Macronutrient Intake

Table 2. Mean Macronutrient Intake(% of TEI) on the Days before the Race and on Race Day (n=10), Means±s, Range

	% Total Energy Intake					
Days	**CHO**		**Protein**		**Fat**	
3 days	48 ± 7	41-63	20 ± 0.5	14-27	32 ± 8	17-43
2 days	49 ± 13	25-63	17 ± 5	10-26	33 ± 10	20-51
1 day	47 ± 10	34-68	19 ± 6	12-30	35 ± 8	21-45
Race Day	66 ± 17*	37-84	13 ± 5	5-24	21 ± 13*	12-50
ANOVA	(F(3,27)=10.530;).		(F(3,27)=2.823;).		(F(3,27)=6.037).	
P value	P=0.000*		P=0.058		P=0.003**	

*Significant difference of CHO intake compared to 3D, 2D and 1D **Significant difference of fat intake compared to 1D

Table 2 indicates the percentage of macronutrient contribution towards diet. There was a significant increase in percentage of CHO intake on the day of the race (66; s=17%) compared to all the previous days. Percentage of fat intake decreased significantly from 1 day before the race (35; s=8%) to race day (21; s=13%). There was no significant difference between the percentages of protein on any of the days. However, when the datawas normalised for body weight, no significant difference was found.

3.4. Correlation

Pearson correlation revealed a strong negative relationship between average CHO intake before the event and race time (r=-0.821; *P*=0.024). The linear regression (y=1.66*+68.153) suggests that for every additional $g.kg^{-1}$BM of CHO consumed the performance time would improve by 1.66 minutes. The R^2 coefficient of determination was strong, suggesting that body weight normalised CHO intake during the 3 days before the event can predict performance in 67.4% of the cases. There was no relationship found between race day CHO intake (r= -0.596; *P*=0.158) and performance or between energy balance and performance (r= -0.621; *P*=0.136).

3.5. Race Day Food Choices and Nutritional Strategies

Race day food diaries revealed that 7 of the participants consumed no food or drinks during the race while the other 3 consumed one energy gel during the event. The main food choice on the morning of the race was porridge or cereal, followed by pasta, banana or sandwich. Most athletes were aware of the importance of their energy levels and although their food choices reflected that, the quantity of food did not. Drink choices of cyclists prior to the event varied from sports drinks to water. Six participants consumed a CHO-electrolyte drink, three of which had a gel also. Three subjects consumed diluted fruit juice before the race and one drank water only.

Pre-race nutritional strategies ranged widely between participants. The most common strategy was keeping energy levels high and stop eating 2 hours before the race followed by a small snack 1 hour or right before the race. Other strategies included no alcohol consumption the night before (2) the use of caffeine (1) and swilling the pre-race drink around the mouth before swallowing it (1). Two cyclists reported no strategy at all. The sources of these strategies reported by the cyclists were common sense (2), experience (2), cycling magazines (3)and internet (3).

4. Discussion

This study examined the dietary intake of club level cyclocross athletes in preparation for and during a league race. The results found that although the cyclists were in positive energy balance in the 3 days leading up to the event, they failed to meet their energy requirements on race day. Reference[25] recommend that between a quarter and half of the of total daily calories should be consumed prior to the event, which assuming an average of 3000 kcal per day would require at least 1500 kcal as the event started at 1pm. The average on race day was 914.2 ± 366.5 kcal (range 542-1679), with the majority of calories coming from CHO.Mean results of the 3 day food diary suggest that the cyclists were in positive energy balance in the days before the race. Energy surplus increased from 3D to 1D suggesting that the athletes were increasing their energy intake in preparation for the race. Conversely, Figure 1 shows that energy intake remained stable, and the positive balance was a result in a reduction of their training load prior to the race rather than an increase in food intake. However, often group data can disguise the practices of individuals[13] and as such the individual results showed that 5 cyclists on 3 days before, 4 cyclists on 2 days before and 2 cyclists the day before were in negative energy. The athletes' energy intake on race day was nearly 50% lower than the energy expended. Seven cyclists commenced the race with sub-optimal energy levels and by the end of the race all cyclists were in negative energy balance.

Relative macronutrient contribution to the diet in the 3 days before race day was 48% carbohydrate, 19% protein and 33% fat. These figures are similar to those reported by[30] for the general UK population. CHO intake was lower than the recommendation of 60-70% and those reported in previous research involving sub-elite athletes[18; 23; 31]. Although on race day it would appear that the energy requirements were met (CHO 66%, protein 13% and fat 21%), this was not reflected in the intake of the cyclists when expressed as $g.kg^{-1}BM$, thus stressing the importance of expressing macronutrient intake in this format rather than a percentage.

Protein requirements of endurance athletes range between 1.2-1.6 $g.kg^{-1}BM$ depending on training volume and intensity[28]. In this study the average protein intake during the days leading up to the event was 1.9 $g.kg^{-1}BM$, whichexceeds the upper limit of the recommended amount for this type of activity.

The literature suggests that CHO and protein should not be compromised and athletes should meet these requirements before the rest of the energy intake being taken up by fats[22]. Race day fat consumption was only 0.3 $g.kg^{-1}BM$ and in line with the findings of[15]. However, fat intake was met and exceeded on all days before the race and it is advised that the cyclists reduce their fat intake to allow them to increase their CHO intake.

The guidelines for dietary intake of CHO for athletes undertaking 60-90 minutes of daily exercise are 5-7 $g.kg^{-1}BM$[11]. Cyclists in this study were barely achieving the lower acceptable limit of these recommendations (mean 5.1 $g.kg^{-1}BM$). These amounts were lower than those found by[18; 23]. However, it should be noted that the inclusion criteria was a minimum of 4 hours of training a week, and although some athletes just about met this minimum level, others reported training as much as 3 hours a day. These higher training volumes would need greater CHO intake of 7-10 $g.kg^{-1}BM$[11] in which case the gap between actual and required CHO is even greater.

Research by reference[20] states that the average exercise intensity during mountain bike racing was around 84% of VO_{2max} with 82% of the race spent above lactate threshold. To the authors knowledge there have been no similar investigations in cyclocross but it is assumed that the intensities would be almost the same. A laboratory study by reference[27] found that 8 sets of 5 minute bouts of exercise at 86% of VO2max resulted in 51% reduction in muscle glycogen. If similar results occur in cyclocross racing it would be crucial to maximise CHOstores prior to competition. This would be especially important as less well trained cycliststend to oxidise more CHO and less fat at high intensities compared to elite cyclists (Hawley & Stepto, 2001). This was further supported in this study where a strong negative relationship was found between average CHO intake (expressed as $g.kg^{-1}BM$) before the event and finishing race time. Although the linear regression suggests that for every additional $g.kg^{-1}BM$ of CHO consumed in the 3 days before the race, there will be a performance improvement of 1.66 minutes, these results should be treated with caution as the top 2 cyclists in the race also reported higher training volumes.

Reference[15] suggest the consumption of 1-4 $g.kg^{-1}BM$ of CHO 1-4 hours before exercise in order to increase muscle and liver glycogen concentrations and contribute towards improved performance. Race day CHO intake in the current study was 2.2±1.2 $g.kg^{-1}BM$ which falls between these limits. However, it is below the 3 $g.kg^{-1}BM$ suggested by reference [16] which showed a 3% increase in performance over those who only consumed 1 $g.kg^{-1}BM$ during their simulated mountain bike test lasting 93 minutes.

Pre-competition meals were in line with the recommendations[8] and were high in CHO and low in fat. Most of the athletes were aware of the importance of their energy levels and although their food choices reflected that, the quantity of food did not. There was a large variance amongst the cyclists in their race day CHO intake (Table 3) which can be attributed to a number of factors such as personal preferences, food and drink tolerances before exercise and previous experiences of gastrointestinal discomfort[15].

The current study observed a lack of dietary strategy amongst the participants. For example during the pre-competition weighing seven of the cyclists reported that they did not need to consume anything during the event as the race only lasted an hour. The cyclists clearly had no knowledge that the consumption of small amounts of CHO during exercise lasting 1 hour can be beneficial[5]. One cyclist reported to swill his pre-race drink around his mouth before swallowing it referring to the beneficial effects of a CHO mouth rinse seen in trials lasting 1 hour[14]. However, the current understanding is that the ergogenic effects of a CHO mouth rinse exist in a fasted but not in a fed state and there is no need to swallow the fluid (Jeukendrup & Willians, 2011).

The above results highlight the lack of nutritional knowledge of club level cyclocross cyclists and the existence of misconceptions with regard to nutritional strategies, amount and type of food consumed, which is also typical of sub-elite triathletes[31] and cross country runners[32]. This lack of knowledge stems from the cyclists basing their strategies on trial and error, previous experiences or on information obtained from the media such as the internet, which seems to be a common theme amongst sub-elite athletes[31; 32]. Reference[24]found a non-significant positive correlation between sources of information and nutritional knowledge and reference[19] found there to be a relationship between the athletes' ability and nutritional knowledge. Both of these studies may explain in some way the better nutritional knowledge and higher training volumes of the top two cyclists in the current study.

5. Conclusions

The primary aim of this study was to investigate the pre and in competition nutritional intake of cyclocross cyclists. This revealed that the cyclists consumed a typical western diet, high in protein and fat which meant that the current guideline of 5-7 g.kg^{-1}BM (or 7-10 g.kg^{-1}BM) for CHO was not met by the majority of the cyclists in this study.

Secondly, the cyclists' nutritional practices in preparation for a race were investigated and while the main theme of the cyclists was "keeping energy levels high", the cyclists had no real nutritional strategies and misconceptions were also common. The main reason for this was gathering information from unreliable sources and relying on tactics that "worked before". Therefore, the biggest challenge for athletes like these cyclists in terms of dietary practices is not only obtaining quality information, but knowing how to apply it to their sport such as using appropriate practices at appropriate times.

This study highlights that published scientific information isstill either not getting through to athletes,is not understood or plainly not followed by athletes at a sub-elite level.

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