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The CEAC-Q for endurance athletes in competition, verification of a useful and time-efficient instrument for knowledge evaluation

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Abstract: Despite strong evidence that increased carbohydrate (CHO) availability promotes endurance performance, athletes frequently report eating less CHO during competition. The absence of practical or time-efficient methods for assessing athletes' understanding of CHO may be a contributing factor to these findings. Therefore, we attempted to validate a novel questionnaire to immediately assess endurance athletes' awareness of competition CHO guidelines. The students completed three subsections of the questionnaire (CHO metabolism, CHO loading, and pre-event meal), with each subsection valued at 15 points. The CEAC-Q was completed by 100 individuals, 56 of whom were women and 44 were men. The total CEAC-Q scores did not differ among the subsections regarding population-level averages for low (0–39%), moderate (39–69%), and high (70–100%) knowledge ($p < 0.001$). The CEAC-Q provides practitioners with a valid and effective psychometric tool for assessing athletes' comprehension of CHO competition standards. This evaluation not only helps to identify knowledge gaps but also offers suggestions for future dietary interventions aimed at improving athletic performance.

Keywords: *Carbohydrates, CEAC-Q, Lifestyle, Sport nutrition.*

1. Introduction

Current dietary guidelines for carbohydrates (CHO) are based on a large amount of research showing the benefits of optimal CHO consumption for endurance performance before and during competition. Despite recommendations with substantial scientific evidence that adequate carbohydrate (CHO) intake can improve endurance performance, endurance athletes have been observed to fail to meet these criteria for competition [1-6]. Nutrition knowledge is an essential component driving general dietary behaviour [7] yet little is understood about endurance athletes knowledge of CHO guidelines and how they relate to practice within competition. Given that runners and triathletes have been shown to lack basic nutrition knowledge [5, 8] ignorance of CHO requirements may be the main contributing factor. We have created a new survey called the Carbohydrates for Endurance Athletes in Competition (CEAC-Q) to support this [6]. Adequate nutrition knowledge is an essential component to drive an athlete's behaviour and optimise general dietary intake [9].

2. Methods

The questionnaire was developed based on the findings of recent sports nutrition research on CHO for endurance sports as well as the current American College of Sports Medicine (ACSM) guidelines. To complete the CEAC-Q, study participants had to be endurance athletes over the age of 18 who were actively training and competing in endurance sports events such triathlons, cycling, and running. The Declaration of Helsinki's criteria were followed in the conduct of this study. Each person online consented to participate and provided written informed permission after receiving the participant information statement. Using the CEAC-Q in Albanian, the current study evaluated an international

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cohort of endurance athletes' current CHO for competitive nutrition knowledge between January and March.

Table 1.
Demographics of endurance athletes and general population.

Characteristic	Frequency (n%)	CEAC-Q score % ± SD	P (Between groups)
All	100		
Gender			< 0.042
Female	56	53 ± 19	
Male	44	45 ± 20	
Age (years)			
18	26	53 ± 19	< 0.001
19	32	52 ± 20	
20	28	45 ± 20	
21-28	14	40 ± 19	
Education			
Highschoolcertificate/ Diploma	53	49 ± 19	< 0.001
Undergraduate	47	50 ± 21	
Postgraduate			
Doctorate			
Sport			
Cycling	31	51± 20	< 0.045
Triathlon	4	42 ±19	
Running	17	51± 20	
Football	36	52± 21	
Other	12	45 ±23	
Competitive level			
Amateur	88	45 ±23	< 0.001
Professional	12	37 ±20	

Table 1 summarizes the demographic information gathered about gender, age, education, sport, competition level, and years of competition, as well as whether athletes had previously worked with a dietitian or nutritionist and their main source of information on sports nutrition and its correlation with CEAC-Q scores.

Table 2.
Carbohydrate for Endurance Athletes during Competition Questionnaire Scoring Sheet (CEAC-Q).

Section 1: Carbohydrate storage		
1.Which factor(s) influence how much carbohydrate our body uses during exercise?	Exercise intensity	52 (High)
	Exercise duration	22
	Environment	3
	Training status (fitness level,years of training)	16
	Carbohydrate never	1(Low)
	Unsure	6
2. Which of the following carbohydrate related factors contribute to fatigue during exercise ?	Low blood sugar levels only	9
	Low muscle glycogen stores only	11
	Low blood sugar AND muscle glycogen	65 (High)
	Carbohydrate not required	7 (Low)
	Unsure	8
3.In a carbohydrate loaded state carbohydrate is stored in the body as ;	Muscle glycogen only	13
	Liver glycogen only	4
	Muscle glycogen (80%) and liver glycogen (20%)	54 (High)
	Muscle glycogen (20%) and liver glycogen (80%)	18
	Carbohydrate is not stored in the body	1 (Low)
	Unsure	10
4. In a carbohydrate loaded state, total carbohydrate storage in the body is	<200 g	11
	200–400 g	24

Section 1: Carbohydrate storage		
approximately:	400–600 g	27
	Carbohydrate is not stored in the body	3
	Unsure	35
5. Which source of carbohydrate stores is used to maintain normal blood sugar during exercise?	Muscle glycogen only	15
	Liver glycogen only	51 (High)
	Muscle and liver glycogen	17
	Carbohydrate stores are not used to maintain blood sugar during exercise	6
	Unsure	14
Section 2: Pre-Competition Carbohydrate Loading		
6. Carbohydrate loading in the days before a competitive endurance event can increase endurance performance by?	Carbohydrate loading cannot increase endurance performance	4
	Increasing maximal speed or power output during prolonged exercise	7
	Delaying the onset of fatigue during the late stages of prolonged exercise	67 (High)
	Unsure	22
7. Carbohydrate loading to maximise glycogen stores is most efective in improving performance in competitive events lasting:	Less than 60 min	5
	60–90 min	11
	More than 90 min	64 (High)
	Carbohydrate loading is unnecessary	9
	Unsure	11
8. When carbohydrate loading before competition, the recommended range of carbohydrate intake per day is?	Less than 4 g per kilogram body mass	3
	5–8 g per kilogram body mass	24
	9–12 g per kilogram body mass	26 (High)
	More than 12 g per kilogram body mass	3
	Carbohydrate loading is never required	6
	Unsure	28
9. When competing WITHOUT carbohydrate loading, the recommended range of carbohydrate intake per day is?	Less than 4 g per kilogram body mass	20
	5–8 g per kilogram body mass	30 (High)
	9–12 g per kilogram body mass	7
	More than 12 g per kilogram body mass	3
	Eating carbohydrate is never required before exercise	9
	Unsure	31
10. To maximise muscle glycogen stores, carbohydrate loading (in combination with a tapering of training loads) is best followed for:	12–24 h before a competition	13
	24–48 h before a competition	54 (High)
	A week before a competition	23
	Carbohydrate loading is never required	2
	Unsure	8
Section 3: Before Competition Carbohydrate Meal		
11. How much carbohydrate should a meal eaten before competition contain	Less than 1 g per kg body mass	6
	1–4 g per kg body mass	38 (High)
	More than 4 g per kg body mass	21
	Eating carbohydrate is never required before exercise	4
	Unsure	31
12. When is eating a meal or snack rich in carbohydrate likely to improve performance?	Before competition lasting LESS than 60 min	9
	Before competition lasting MORE than 60 min	53 (High)
	Never	2
	Always	25
	Unsure	10
13. Eating a meal rich in carbohydrate in the hours before competition specifcally helps to:	To increase MAINLY muscle glycogen stores	28(High)
	To increase MAINLY liver glycogen stores	17
	Increase both muscle and liver glycogen stores	27
	Eating carbohydrate before competition has no signifcant efect on carbohydrate stores	4
	Unsure	24
14. A meal rich in carbohydrate should be eaten	Less than 1 h before	1

Section 1: Carbohydrate storage		
how many hours before competition	1–4 h before	58 (High)
	More than 4 h before	25
	Eating carbohydrate is never required before exercise	3
	Unsure	10
15. Which of the following statements is correct regarding carbohydrate intake and gastrointestinal distress:	Eating carbohydrate before and during competition always results in gastrointestinal distress	2
	The gut can NOT be trained to tolerate carbohydrate before and during competition	7
	The gut CAN be trained to tolerate carbohydrate before and during competition	79 (High)
	Unsure	12

2.1. Section 1: Carbohydrate Metabolism and Utilization

Question 4 showed low knowledge (F), questions 1, 2, 3 and 5 showed a reasonable comprehension of CHO metabolism and utilization. Particularly, there was little understanding of the overall storage of carbs (Question 4, 35% correct), the percentage of carbohydrates in the liver and muscle (Question 4, 54 % correct), and the function of the liver's glycogen reserves (Question 5, 51 % correct). The identification of blood sugar and muscle glycogen as factors linked to fatigue (Question 2, 60% correct) showed a moderate level of understanding. Overall awareness of the factors influencing carbohydrate usage was moderate (Question 1, 42% right), notwithstanding the uneven frequency of properly answered sub-questions. Although the length and intensity of knowledge were high (Question 1, 84% and 83% correct, respectively), the environment and training state were only moderately correctly identified as important factors (Question 1, 55% and 53% correct, respectively).

2.2. Section 2: Carbohydrate Loading

Questions 8 and 9 demonstrated a low level of awareness on CHO-loading, while question 10 demonstrated a moderate level of understanding (Table 2). The determination of the quantity of carbohydrates needed for carbohydrate loading (Question 8, 26% correct) and for situations in which carbohydrate loading is not necessary (Question 9, 30 % correct) specifically demonstrated a lack of understanding. The average amount of time needed for carbohydrate loading was moderately understood (Question 10, 54% correct).

2.3. Section 3: Before Competition Carbohydrate Meal

While questions 11 and 14 demonstrated a good understanding of CHO in the pre-event meal, questions 12 and 13 demonstrated a poor awareness of it (Fig. 2, Table 2). The identification of

1-4 g/kg CHO in the meal before competition (Question 11, 38% accurate) and the time period of 1-4 hours prior to exercise (Question 14, 58% correct) in particular showed a respectable level of expertise. We discovered that eating CHO in the hours before exercise is mostly done to restore liver glycogen levels (Question 13, 28% correct) and that little is known about when pre-event carbohydrates are likely to increase performance (Question 11, 38% correct).

3. Discussion

Knowledge levels were classified as low (less than 40%), intermediate (between 41 and 70%), and high (more than 70%). We discovered that knowledge levels were not significantly predicted by demographic factors. Our current findings of athletes' average CEAC-Q scores, which are similar to our validation study's findings of 46 ± 19% [10] support the idea that most athletes lack expertise (Figure 1). Although there were no variations in knowledge between CEAC-Q section scores, we did find significant disparities in understanding of specific questions. This implies that people are more likely to know less about nutrition if they are not exposed to as many reliable information sources. We employed a cohort of endurance athletes to assess the population's awareness of carbohydrate guidelines for competition using the previously validated CEAC-Q questionnaire [10]. Three knowledge levels were distinguished: low (less than 40%), moderate (between 41 and 70%), and high (more than 70%). We discovered that knowledge levels were not significantly predicted by demographic characteristics. The majority of the athletic population has limited knowledge, according to our most recent data on average CEAC-Q scores among athletes, which confirms the 46 ± 19% [10] results of our validation research (Fig. 1).Our results on CHO intake are in line with what has been previously documented in the literature, which indicates that endurance athletes typically consume 3.3–5.8 g · kg−1 [6, 7, 10-14] for CHO-loading and 12–94 g · h−1 [10-12, 15-17] for CHO during competition. The study's primary conclusion is that there was no correlation between endurance athletes' food habits during competition and their understanding of the recommended CHO consumption. To the best of our knowledge, this is the first study conducted in Tirana to link athletes' theoretical knowledge and practice with their competitive CHO consumption. Although some endurance athletes were able to identify the latest CHO norms, this information isn't always used in real-world situations. Our findings imply that other obstacles and enabling factors might be just as significant in converting scientific knowledge into the best dietary practices for endurance athletes competing, even though theoretical knowledge is generally regarded as a fundamental component of best practice in nutrition [18]. A new frontier in the relationship between knowledge and practice is revealed when food intake is evaluated in conjunction with the CEAC-Q [19]. It is evident that endurance athletes have gaps in their theoretical understanding and dietary habits regarding CHO loading and ingestion during competition. Despite demonstrating disparities in knowledge across various demographics (Table 1), their predictive ability was poor, and in certain situations, their therapeutic applicability was in doubt. Overall, though, they imply that having access to high-quality information is linked to having more knowledge. When assessing athletes' degree of nutrition awareness, demographics are usually a significant factor [18]. The CEAC-Q scores of male athletes were significantly higher than those of female athletes; however, this difference is equivalent to an average of 0–5 more correct answers. In contrast to Trakman et al. [20] who found no difference in general nutrition knowledge between amateur and professional athletes, we found significant increases in CEAC-Q scores in athletes competing at a higher level and with more experience, with an average difference of 12 points between amateur recreational and professional athletes. Completing the CEAC-Q may initiate a series of thought processes that result in novel understandings or information [21]. Given their innate desire to obtain a competitive edge, athletes may attempt to fill in knowledge gaps between exams [22]. A different and minor random mistake in repeat tests implies strong reliability and construct validity since it suggests learning processes at work, and scores are expected to rise after self-education [23, 24]. In order to maximize endurance performance, nutritionists will be able to better understand why athletes don't meet required CHO intakes and create more effective, enhanced athlete nutrition education materials and programs [25].

4. Conclusion

In summary, our results show that there is a disconnect between practice and understanding of CHO competition standards. The causes of the mismatch are still unclear, which emphasizes the necessity for qualitative research examining athletes' justifications for the discrepancy. This could lead to fresh perspectives on how athletes can enhance their performance and pinpoint their potential, opportunities, and motivational requirements to maximize their dietary habits.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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