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Effect of Combined Intra-Session Glucose and Fructose Intake on the Performance of Young Super-Sprint Triathletes: A Randomised, Crossover, Blind, Placebo-Controlled Study

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Abstract: Carbohydrate intake is a commonly used strategy in sports, and supplementation for triathletes includes pre-competition, intra-competition, and post-competition intake. The consumption of fructose–glucose improves intestinal transit and gastric emptying. The main purpose of this study was to analyse the effect of intra-session carbohydrate intake in triathletes training in the super-sprint modality. Eleven adolescent triathletes (boys, n = 9, 14.6 years; girls, n = 2, 15.2 years) participated in a crossover, randomised, and blind study on the effect of supplementation with 45 g of carbohydrates (glucose:fructose; 1:2) The participants performed two super-sprint tests (swimming 250 m, cycling 6 km, and running 2 km) with a rest period (2 h) during which they drank a placebo drink (PG) or a carbohydrate drink (SG). The effect on blood glucose was evaluated, but there were no significant changes in glucose values. However, it was higher in the SG after supplementation. No significant differences were found in the cycling, swimming, and running tests, except for RPE in the swimming sector ($p < 0.05$). Neither were significant changes in body weight observed during the assessments. Supplementation with 45 g of liquid carbohydrates composed of fructose and glucose in a 2:1 ratio was not effective for delaying fatigue or improving performance markers or blood glucose levels in super-sprint triathletes.

Keywords: triathlon; performance; supplementation; fructose; glucose

1. Introduction

Triathlon is a sport that primarily relies on the energy substrate glycogen because it involves moderate to high intensity for an extended period. There are different triathlon distances, such as long distance (3.8 km swimming, 180 km cycling, and 42.2 km running), half distance (1.9 km swimming, 90 km cycling without drafting, and 21 km running), Olympic (distance 1.5 km swimming, 40 km cycling, and 10 km running), sprint distance (0.75 km swimming, 20 km cycling, and 5 km running), and super-sprint distance (300 m swimming, 10 km cycling, and 2.5 km running [1,2]. Physical demands can vary in physiological requirements, especially glycogen metabolism [3]. Therefore, the effective intake of carbohydrates is essential for improving athletic performance. In this regard, the established intake of carbohydrates can range from 3 g/kg of body weight to 12 g/kg, depending on the type of training and the athlete's periodisation [4]. In addition, the strategies include both pre-competition, intra-competition, and post-competition intake [5]. In addition, the strategies include both pre-competition, intra-competition, and post-competition intake. It has been established that before competing, they should ingest CHO with a low glycaemic index [6]. It is worth noting that it is important to start exercise with full glycogen stores. Moreover, there is a metabolic window in which glycogen synthesis is higher in the 2 h after exercise, and the CHO should have a high glycaemic index [7].

During competition, a high intake of exogenous CHO of 70–90 g/h will prevent the depletion of endogenous CHO [8], allowing savings of muscle and liver glycogen, thus avoiding possible hypoglycaemia and improving performance [9]. However, the availability of glycogen will depend primarily on the action of insulin and glucagon. This is why a high-GI CHO load can produce a high insulin response, leading to reactive hypoglycaemia, while a low-GI CHO intake could have low availability [10]. In this regard, studies support the combination of high- and low-GI CHOs [11]. A recent investigation compared the effect of a honey-based drink (glucose–fructose) to a glucose-based drink, and it was observed that the insulin curve was lower [12]. Elsewhere, the combined intake of glucose and sucrose or maltodextrin and fructose has been reported to show the highest endogenous CHO oxidation compared with other forms of CHO. Studies indicate that a ratio of 1–1.2 of maltodextrin to 0.8–1 of fructose is optimal [13]. Jeukendrup et al. reported that the intake of fructose–glucose resulted in smoother delivery and improved gastric emptying [14]. Therefore, this combination would increase the rate of CHO oxidation as glucose would use the DGLT1 transporter and fructose GLUT5 [15]. In addition, gastrointestinal problems could be reduced and, consequently, performance improved [16]. In this regard, it has been reported that the absorption rate could reach up to 90 g/h [8]. Another aspect to consider is the concentration of CHO in the sports drink. Previous authors have indicated that it should be palatable and have a concentration of 4–8% CHO, which favours the absorption of CHO without affecting gastric emptying. Athletes usually consume drinks because they are less heavy before competition, and they also help them to rehydrate during exercise, although Rowlands et al. reported that triathletes preferred to intake gels [17].

Research varies as to the timing of CHO intake in triathletes. Rowland et al. investigated the effects of 2:1 (glucose/fructose) supplementation during the race [17]. Meanwhile, another investigation obtained improvements in the running section after supplementing with maltodextrin+glucose in the cycling phase [18]. Alternatively, Smith et al. 2002 found an increase in blood glucose, but not in performance, after the intake of a 10% glucose solution prior to a swimming event [19]. In this regard, it is interesting to study prior supplementation because several triathletes do not reach the minimum levels of CHO intake in the Olympic-distance race [20]. The higher intensity of exercise over short distances means greater dependence on CHO substrate. Although this is evident, no previous research on CHO intake in super-sprint triathletes has been found in the scientific literature.

Furthermore, all of these strategies have been investigated in senior athletes, with little literature on the subject in developing athletes. In addition, there is controversy surrounding the ergogenic effect of CHO during exercise; while some studies have reported benefits in endurance performance [21], others have not reported such improvements [22]. Regarding the effect of pre-exercise CHO supplementation, a recent study did not observe any effect of the combination of glucose + fructose pre-exercise in healthy individuals [23]. Additionally, the study indicated that research is needed on performance athletes. A systematic review with meta-analysis showed that there was a large effect of CHO supplementation on performance [24]. Nevertheless, this effect was mostly observed in long-duration tests; therefore, it is necessary to observe if there is an effect in short-duration tests. It is important to note that metabolism in adolescence can fluctuate depending on several factors. First, the growth of bones and skeletal muscles involved in respiration is a factor, as this will directly affect oxygen consumption [25]. Moreover, the organs involved in aerobic metabolism, such as the heart and lungs, are not yet fully developed. Nonetheless, there is greater dependence on the lipolytic oxidative system due to lower glycolytic enzymatic activity, resulting in greater glycogen savings compared to those of adults during exercise [26–28]. The percentage of VO_2max at the aerobic threshold decreases as the athlete matures in puberty, progressively increasing anaerobic capacity as well as fatigue resistance [29]. In addition, after pre-exercise glucose intake, the levels in children and adolescents are higher than in adults, suggesting that insulin sensitivity is lower [30].

The greater reliance on the lipolytic oxidative system and the lower insulin sensitivity will modify the demands of CHO and the effect of its intake on performance. Therefore, it is necessary to observe the ergogenic effect of CHO intake in adolescents. In addition, the super-sprint modality is on the rise, with scarce scientific literature on the ergogenic effect of CHO intake in this modality. Therefore, it could be hypothesised that mixed CHO supplementation would increase performance in adolescents. Thus, this study aimed to observe the effect of intra-session CHO intake on performance in young super-sprint triathletes.

2. Materials and Methods

2.1. Study Design

This randomised, crossover, blind, placebo-controlled study lasted 3 weeks (Figure 1). Participants completed two super-sprint trials (250 m swimming, 6 km cycling, and 2 km running) with a rest period (2 h) during which they consumed a placebo drink (PG) or a carbohydrate drink (SG), with the aim of assessing performance loss (fatigue).

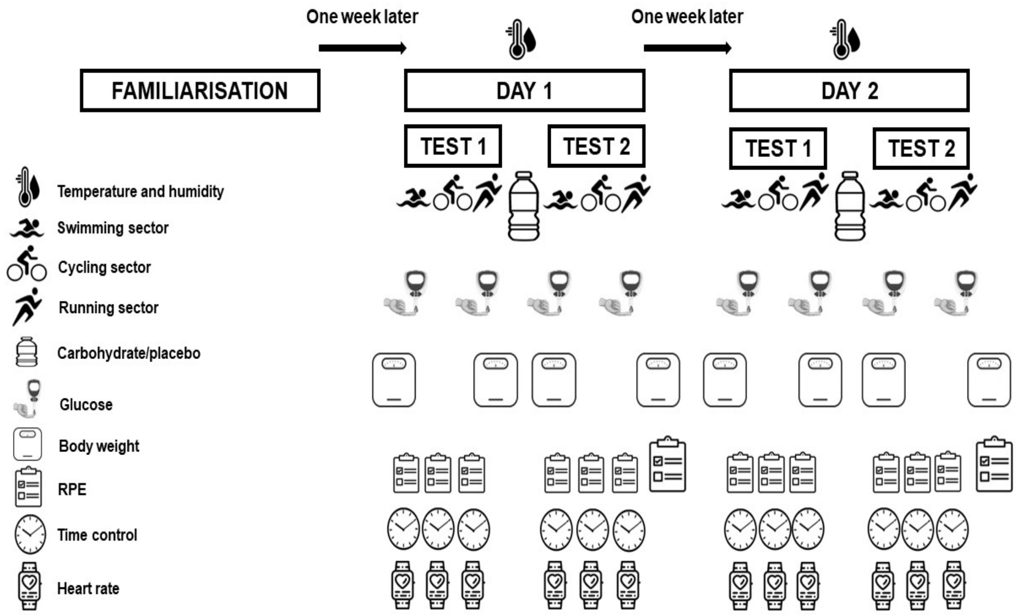

Figure 1. Study design. RPE: rate of perceived exertion.

In week 0, to reduce possible improvement due to familiarity with the test, the participants performed the protocol without supplementation to learn the test. A week later, in week 1, after the sample was randomised, the participants were divided into two groups (PG and SG) and carried out the two trials with a rest period during which they consumed the placebo or carbohydrate drink. A week later, in week 2, the participants repeated the test, crossing the groups, to experience both conditions.

Body weight and baseline blood glucose were measured before and after each trial. During the test, heart rate and speed were monitored in each sector, and the subjective perception of effort (RPE) was evaluated (Figure 1).

2.2. Sample

Eleven young triathletes (nine boys and two girls) participated in the present study. The sample characteristics are shown in Table 1. All of the participants were triathletes from the same club located in Extremadura (Spain). All of the participants and their parents were informed about the purpose of the study and signed a consent form before enrolling. The protocol was reviewed and approved by the Bioethics Committee of the University of Extremadura following the guidelines of the Helsinki Declaration, updated at the World

Medical Assembly in Fortaleza (2013) for research on human subjects (Approval code: 233/2019; (Date of approval: 08/10/2019)). Each participant was assigned a code in the collection and processing of samples in order to maintain their anonymity. Participants reduced the volume and intensity of their training during the week of evaluations to perform the tests with the least possible fatigue.

Table 1. Anthropometric and training characteristics of the sample.

Parameters	Boys (n = 9)	Girls (n = 2)
Years (age)	14.6 ± 1	15.2 ± 1
Height (m)	171.5 ± 1.9	163.7 ± 2.4
Weight (kg)	60.40 ± 10.82	49.28 ± 5.8
BMI	14.7 ± 1.8	15.5 ± 2.1
Swimming (m)	126,200	126,200
Cycling (km)	3300	3300
Running (km)	1072	1072
Experience (years)	6	6

To participate in the present study, subjects had to meet a series of criteria: (a) more than 4 years of experience in the sport; (b) to have a competitive level; (c) not to suffer from any type of disease; (d) not to consume medication, alcohol, or drugs; (e) not to smoke; and (f) to have ingested carbohydrates after training at some point.

Firstly, 18 triathletes signed the informed consent to participate in the study. However, 5 of them were excluded due to not having time available for the evaluations, and 2 were excluded due to illness or injury during the investigation (Figure 2). Therefore, 11 triathletes participated in the present study. The randomisation of the groups was carried out using the following link: https://www.randomizer.org (accessed on 15 December 2023).

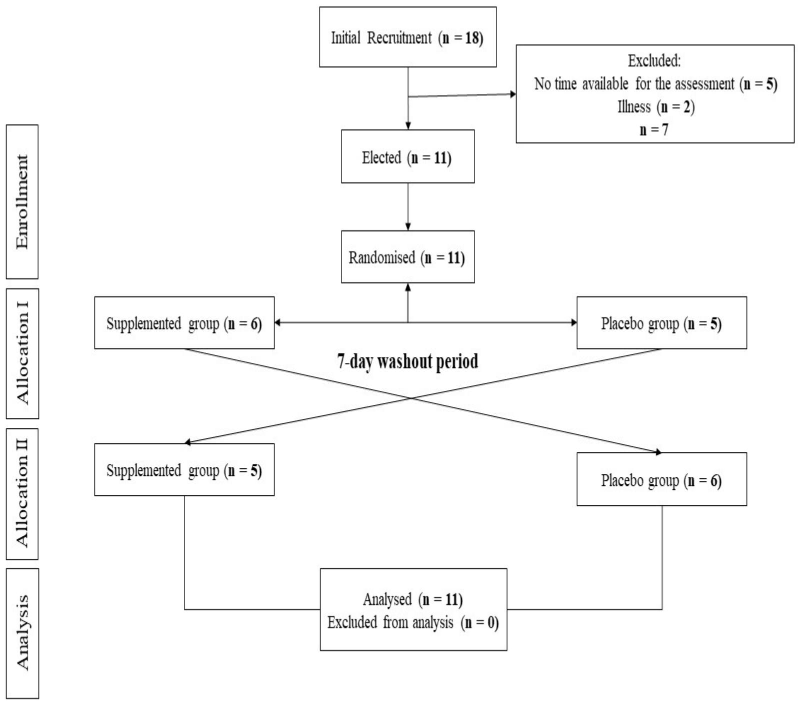

Figure 2. Participants flow diagram.

2.3. Nutritional Intake on Previous Days

The 6 days prior to the tests, the participants followed nutritional guidelines developed by a nutrition professional. These guidelines specified the quantity and examples of dishes. The participants had to ingest approximately 7 g/kg/d of CHO, 1.6 g/kg/d of protein, and 0.8 g/kg/d of fat. Table 2 shows the mean of the 6 days of each week in the intake of macronutrients.

Table 2. Macronutrient intake before tests.

Parameters	Day 1	Day 2
Carbohydrate (g)	421 ± 71	434 ± 60
Carbohydrate (g/Kg)	8	7
Protein (g)	91 ± 15	95 ± 12
Protein (g/Kg)	1.6	1.6
Fat (g)	48 ± 8	45 ± 6
Fat (g/Kg)	0.8	0.7

2.4. Anthropometry

Weight, height, and BMI were evaluated. Weight was evaluated before and after each test (test 1 and 2). For this, a scale (Xiaomi Mi Smart Scale 2, Xiaomi, Shenzhen, China) was used, which the subjects stepped on barefoot, and the weight was recorded. The difference in weight between the tests (pre- and post-test) was considered to assess the amount of fluid eliminated.

2.5. Test

Super-sprint triathlon tests were conducted consisting of 250 m of swimming in a water reservoir, 6 km of cycling, and 2 km of running. The tests were conducted in the same place, with the same route and distance previously reviewed by two coaches. The weather conditions on both days and the route profile are shown in Table 3. The time of the transitions was included in the total time for each sector and the test.

Table 3. Climatological characteristics and race profile.

	Day 1		Day 2	
	Test 1 (n = 11)	Test 2 (n = 11)	Test 1 (n = 11)	Test 2 (n = 11)
Temperature (°C)	19	24	18	23
Humidity (%)	48	37	77	61
Running sector profile				
Elevation (m)	5			
Maximum slope (%)	7			
Cycling sector profile				
Elevation (m)	20			
Maximum slope (%)	14			

2.6. Blood Glucose Assessment

Similarly to body weight, blood glucose was measured before and after each test (Figure 1). A disposable lancet (Elinic, Albert Lea, MN, USA) was used for glucose measurement. Capillary blood samples were collected after expelling the first drop of blood through a digital puncture on the medial side of the ring fingertip. Blood glucose concentration was measured through photometric reflectance in a portable glucose analyser (Acofarma, Terrassa, Spain). All blood glucose measurements were taken from the fingertips of the left hand.

2.7. RPE and Heart Rate Assessment

Internal load was monitored during the tests in all sectors by evaluating the mean and maximum heart rate (HR) (Garmin; Olathe, KS, USA), as well as the subjective perception of effort (RPE) using the Borg scale (0–10 points) [31]. Participants wore an HR sensor band (Garmin; Olathe, KS, USA). The HR sensor models differed among athletes. Data were exported via Bluetooth to the Garmin Connect platform. Participants indicated on the HR monitor when they finished each sector for subsequent evaluation. Likewise, during the transition and at the end of the test, each participant was asked about their subjective perception of effort in the test.

2.8. Carbohydrate Intake and Placebo

During the break between tests on days 1 and 2, participants ingested a beverage depending on the group (SG or PG). The SG ingested in 500 mL of water 45 g of carbohydrates (glucose:fructose; 1:2) from the ND4® brand (per 100 g 338 kcal, carbohydrates 75 g, protein 7.5 g, fat 0 g, and salt 3.2 g). On the other hand, the PG ingested sweeteners (Bolero Advanced Hydration®, Bolero & Company, Tbilisi, Georgia) with the following nutritional information: 2 kcal; fat: 0 g; carbohydrates: 0 g; protein: 0 g; salt: 0.0025 g. Both liquids had a similar taste (apple) and were collected in bottles with the same design and colour to avoid athlete interpretations [9].

2.9. Statistical Analysis

The data were processed using IBM SPSS 22.0 Statistics (IBM Corp., Armonk, NY, USA). GraphPad Prism 8 was used for the figures. A descriptive analysis was performed to show the means and standard deviations. The normality distribution of the variables was analysed using the Shapiro–Wilk test, and the homogeneity of variances was analysed using the Levene test.

The percentage change was determined for the total times and each sector. Student's *t*-test for independent samples was performed on the percentage changes. For the rest of the parameters, a two-way ANOVA (group effect vs. time effect) was used to show the differences between the variables. For the time effect variable in glucose, the Bonferroni post hoc test was applied. The effect size was calculated using partial eta squared ($\eta 2$), where 0.01–0.06 was a small effect size, 0.06–0.14 was a moderate effect size, and >0.14 was a large effect size [32]. The $p < 0.05$ differences were considered statistically significant. The post hoc statistical power analysis used the GPower program (version 3.1). Post hoc statistical power for an alpha set at 0.05 was 0.324 for two-way ANOVA tests.

3. Results

The following are the results obtained during the investigation. Figure 3 represents the glucose concentrations before and after the tests. No significant differences were observed. However, after supplementation (grey shading), an increase in the SG was observed.

Table 4 shows the data for average pace, total time, and RPE after the swimming sector in both tests. There were differences between groups and between tests in RPE, which were higher in the SG ($p < 0.05$).

Table 4. Performance in the swimming sector.

Parameters	Time	PG	SG	Group Effect	Time Effect	Group × Time
Pace (min/100 m)	Test 1 Test 2	1.45 ± 0.15 1.41 ± 0.09	1.41 ± 0.06 1.40 ± 0.12	0.557	0.492	0.597
Total time (min)	Test 1 Test 2	3.65 ± 0.25 3.52 ± 0.23	3.53 ± 0.12 3.58 ± 0.29	0.695	0.597	0.270
	%	−3.45 ± 3.36	1.59 ± 7.17	-	-	-
RPE (pto)	Test 1 Test 2	7.00 ± 1.00 7.88 ± 0.60	7.50 ± 1.17 8.22 ± 0.83	0.186 #	0.013 ##	0.789

RPE: rate of perceived exertion; PG: placebo group; SG: supplemented group; ##: large effect size; #: medium effect size.

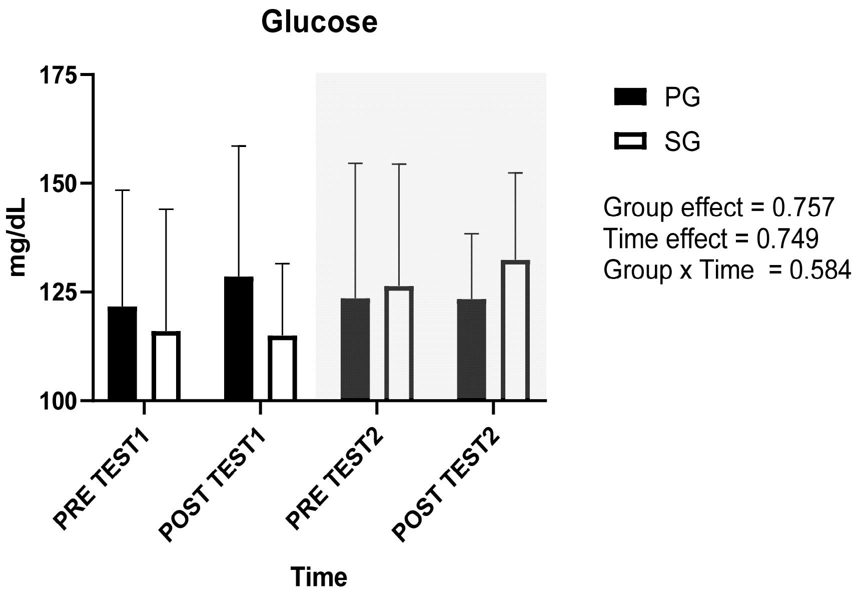

Figure 3. Evolution of blood glucose during tests 1 and 2. The glucose concentrations after supplementation appear in shading. PG: placebo group; SG: supplemented group.

Table 5 shows the average pace, maximum speed, total time, heart rate, and RPE in the cycling sector. No significant differences were observed in this sector. However, the total time slightly increased in both groups.

Table 5. Performance in the cycling sector.

Parameters	Time	PG	SG	Group Effect	Time Effect	Group × Time
Average speed (km/h)	Test 1 Test 2	31.67 ± 1.93 32.02 ± 30.72	31.20 ± 1.65 30.72 ± 1.37	0.234	0.929	0.576
Max speed (km/h)	Test 1 Test 2	51.25 ± 3.70 50.34 ± 3.48	51.25 ± 6.65 52.40 ± 3.09	0.477	0.210 #	0.475
Total time (min)	Test 1 Test 2	10.36 ± 0.62 10.47 ± 0.60	10.47 ± 0.75 10.97 ± 0.58	0.285	0.286	0.482
	%	2.624 ± 5.59	1.89 ± 6.75	-	-	-
Average heart rate (bpm)	Test 1	175.87 ± 14.55	172.00 ± 10.80	0.817	0.695	0.632
	Test 2	175.40 ± 15.20	176.75 ± 11.08			
Maximum heart rate (bpm)	Test 1 Test 2	189.33 ± 8.11 187.00 ± 10.29	183.33 ± 9.30 187.00 ± 7.61	0.368	0.734	0.523
RPE (pto)	Test 1 Test 2	8.12 ± 0.64 8.40 ± 0.54	8.11 ± 0.78 8.75 ± 0.50	0.458	0.111 #	0.515

RPE: rate of perceived exertion; PG: placebo group; SG: supplemented group; #: medium effect size.

Table 6 shows the external load (pace, maximum speed, and total time) and internal load (heart rate and RPE) parameters in the running sector. No significant differences were observed. However, the average pace was higher in the PG, and the total time was higher in the SG.

Table 7 shows the total test time, weight loss, and total RPE. There were differences in RPE when both tests (test 1 and 2) were compared, with the score in test 2 being higher.

Finally, Figure 4 shows a graphical representation of the evolution of the participants' weights throughout the study.

Table 6. Performance in the running sector.

Parameters	Time	PG	SG	Group Effect	Time Effect	Group × Time
Average pace (min/km)	Test 1 Test 2	4.06 ± 0.15 4.09 ± 0.24	4.56 ± 0.75 4.49 ± 0.82	0.098	0.947	0.856
Max pace (min/km)	Test 1 Test 2	3.25 ± 0.23 3.40 ± 0.27	3.68 ± 0.39 3.73 ± 0.65	0.067	0.582	0.796
Total time (min)	Test 1 Test 2	8.07 ± 0.51 8.10 ± 0.57	9.06 ± 1.26 8.99 ± 1.46	0.064	0.966	0.913
	%	−0.780 ± 5.58	−0.576 ± 4.98	-	-	-
Average heart rate (bpm)	Test 1 Test 2	186.80 ± 10.18 190.00 ± 9.56	183.50 ± 13.12 187.75 ± 8.05	0.580	0.460	0.916
Maximum heart rate (bpm)	Test 1 Test 2	193.60 ± 8.73 195.00 ± 9.92	199.75 ± 8.34 194.25 ± 6.18	0.516	0.621	0.409
RPE (pto)	Test 1 Test 2	7.80 ± 1.09 8.80 ± 8.36	8.50 ± 0.57 8.75 ± 0.95	0.459	0.165	0.395

RPE: rate of perceived exertion; PG: placebo group; SG: supplemented group.

Table 7. Total super-sprint test time, weight loss, and total subjective effort perception.

Parameters	Time	PG	SG	Group Effect	Time Effect	Group × Time
Total time (min)	Test 1 Test 2	22.69 ± 1.75 22.35 ± 1.43	22.51 ± 1.51 22.40 ± 1.80	0.909	0.679	0.835
	%	0.258 ± 3.49	0.734 ± 4.25	-	-	-
Weight loss (kg)	Test 1 Test 2	0.46 ± 0.24 0.41 ± 0.22	0.52 ± 0.31 0.40 ± 0.28	0.779	0.336	0.684
RPE total (pto)	Test 1 Test 2	8.00 ± 0.00 8.77 ± 0.44	8.20 ± 0.63 9.00 ± 0.50	0.191 #	<0.001 ##	0.944

RPE: rate of perceived exertion; PG: placebo group; SG: supplemented group; ##: large effect size; #: medium effect size.

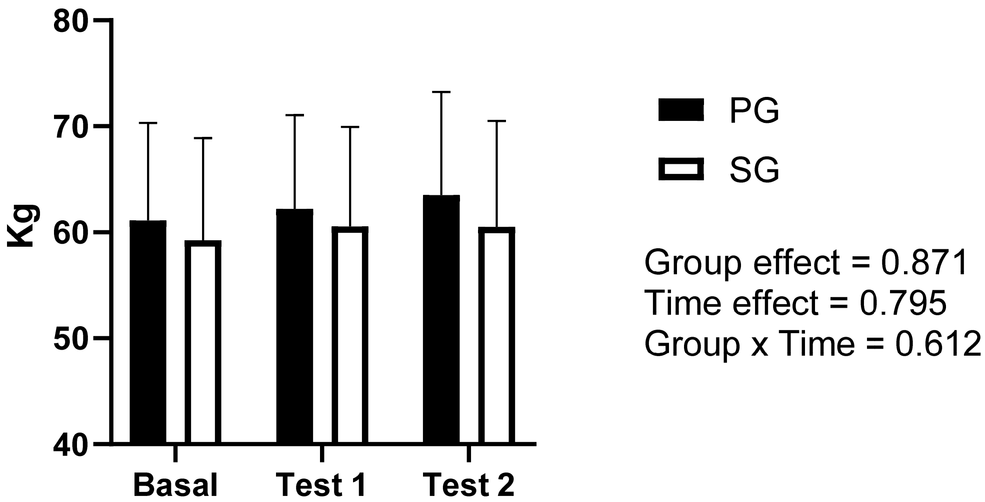

Figure 4. Evolution of the participants' weights throughout the study. PG: placebo group; SG: supplemented group. Basal: basal measurement.

Figure 4 shows the weight of the athletes at the baseline assessment (familiarisation) before starting the carbohydrate loading for test 1, as well as in both tests. Although there is a positive trend in the weights, no significant differences were observed.

4. Discussion

The objective of this study was to evaluate the effect of carbohydrate supplementation (glucose:fructose 1:2) on fatigue in young super-sprint triathletes.

To achieve this, a double-blind, randomised trial was conducted, in which each athlete performed two super-sprint triathlons separated by 90 min of recovery in which they ingested 45 g of the product, as well as a 20 min regeneration protocol on a roller at 40–50% of VO_2max immediately after the first triathlon.

Before discussing the results, it should be noted that for years, pre- and intra-exercise carbohydrate supplementation in endurance sports has been proven to be a reliable and safe tool for improving athletic performance [33]. Among the various strategies and dosing regimens for carbohydrate administration, 45 g/h has been reported to be an effective and safe amount for improving endurance [1].

In recent years, research in the field of sports nutrition has been investigating the effects of combined fructose and glucose intake compared to the intake of glucose or polymers derived from it alone [34]. In this regard, it has been proven that the combination of glucose and fructose during exercise can induce favourable responses in metabolism, substrate utilisation, and gastrointestinal symptoms [35]. Thus, the biochemical and nutritional characteristics of fructose, as well as its obligatory passage through the liver, seem to exert positive responses on the glycaemic response, which, in combination with glucose intake, can favour performance in endurance modalities [34].

It should also be considered that to maximise these nutritional properties, the typology, nature, and intensity of the sports modality play a key role, as the metabolism of carbohydrates during exercise is directly dependent on them. In the case of super-sprints, it is a modality that has a total duration of 25–35 min in well-trained athletes [36], with the men's world records being around 23 min. The men's events consist of 300 m of swimming, 8–10 km of cycling, and 2.5 km of running.

Regarding supplementation, a total of 45 g was ingested in a single dose between both super-sprint trials. The 45 g had a 2:1 ratio of fructose to glucose, so each participant ingested a total of 30 g of fructose and 15 g of glucose. In this respect, the amount ingested by the participants is slightly lower than the amounts advised and reported in the literature [37,38] and, additionally, it was ingested in the post-recovery period after the first effort and not during athletes performance.

In this study, the times recorded by the participants were similar to those reported in the literature (PG: 22.69 $\pm$ 1.75 min; SG: 22.51 $\pm$ 1.51), and no improvements were observed in the total times with carbohydrate supplementation either in the total time or in the time of the different segments or partials of the trial.

These results were supported by the observations related to blood glucose, which was not affected by supplementation, although a slight positive trend was observed in blood glucose values in the SG (Figure 3).

The only differences observed were in the RPE derived from the water segment, which increased after supplementation in the SG but without any effects on any other parameter evaluated. Considering that there were no effects on external load parameters, the increase in RPE could have been due to a greater accumulation of lactate because of the supplementation, as the duration of the segment in the SG was 3.58 $\pm$ 0.29 min, coinciding with durations of effort with a greater involvement of anaerobic glycolytic processes. In this regard, it has been reported that the duration of the super-sprint modality is much shorter than that recorded in Olympic triathlons, with a significantly higher intensity where the anaerobic threshold is exceeded in some phases of the test involving anaerobic metabolism [36].

Also, it is worth noting the increase in heart rate in the SG in the cycling sector, which, although not significant, rose by an average of 4 bpm at intensities close to maximum, as well as the increase in the maximum heart rate recorded in this sector, which could be an indicator of improvement in myocardial function [39].

These possible effects were accompanied by a decrease in the maximum heart rate in the running sector in the SG by 4 bpm, as well as a slight improvement in the pace of trial 2, but statistical significance was never reached at any time.

Unlike long-distance triathlons, which can last several hours, the super-sprint modality has a much shorter duration, with much higher exercise intensities in which glycolytic processes have a greater direct effect on athletic performance [36].

It is well-known in the literature that as exercise intensities increase, the muscular glycolytic demand increases, and the importance of having adequate intramuscular glycogen levels prior to the start of exercise is even greater [40].

In the case of this study, the athletes performed a loading protocol of around 7 g/Kg of weight from 6 days before the start of the test. This type of load has been proven in the literature to be a reliable and effective tool for significantly increasing glycogen levels, with weight increases of around 1 Kg having been reported with 3 days of loading [41].

Figure 4 shows a non-significant increase of more than 1 kg on average in both groups when comparing the baseline assessment (before starting the carbohydrate load) with the weights of both tests. These data are in agreement with those observed by Roulillier et al. [41] and could represent a weight gain due to excessive glycogen accumulation, which has been reported in the literature as a common occurrence [42]. This would support the idea that supplementation with so few carbohydrates in this type of test and with high initial glycogen levels is ineffective.

In addition, the total amount administered to the subjects in the SG was 45 g, with 30 g of fructose and 15 g of glucose. In this respect, there is currently agreement regarding the need for higher carbohydrate intakes to obtain an ergogenic effect. Thus, intakes of between 90 and 120 g of carbohydrates per hour of physical activity have been recommended [43], as well as significantly higher intakes prior to exercise [44]. With these amounts, it has been evidenced that improvements occur both at the ergogenic level and in fatigue and recovery levels. This may be another factor that helps to explain the results obtained.

Lastly, several limitations should be acknowledged in this study. Firstly, the relatively small sample size of eleven triathletes could limit the generalisability of the findings to a broader population of triathletes. Additionally, the focus on triathletes training in the super-sprint modality may restrict the applicability of the results to athletes competing in other triathlon distances or sports. Furthermore, while the study evaluated the effect of supplementation with a specific carbohydrate drink during training sessions, the broader dietary habits of the participants were not accounted for, which could influence the outcomes observed. Finally, statistical power was too low. Thus, the data obtained should be interpreted with caution. Studies in this field are limited, and further research is needed in this area.

5. Conclusions

Based on the results obtained, it can be concluded that supplementation with 45 g of liquid carbohydrates composed of fructose and glucose in a 2:1 ratio may not be effective for delaying fatigue or improving performance markers or blood glucose levels in super-sprint triathletes who have performed a carbohydrate loading protocol of 7 g/Kg/day.

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