http://dx.doi.org/10.1590/1678-9865201932e180056

ORIGINAL

Ingestion of a drink containing carbohydrate increases the number of bench press repetitions

A ingestão de uma bebida com carboidrato aumenta o número de repetições no exercício supino reto

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ABSTRACT

Objective

The aim of this study was to analyze the effects of carbohydrate ingestion prior to exercise on the number of bench press repetitions.

Methods

Eight male physically active (21.3±2.7 years, 176±5cm, 73.12±6.12kg), with a minimum experience of at least one year exercising regularly, visited the laboratory at three moments. During the first visit, candidates went through their anthropometric evaluation and the application of their maximum number of bench press repetitions. The experimental tests were performed during their second and third visits in a crossover and blind study. The participants performed the maximum number of repetitions with an intensity of 70% of their maximum repetition strength. One hour before the experimental trials, participants randomly ingested a solution containing either carbohydrate or a placebo.

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How to cite this article

Santos MMP, Spineli H, Bastos-Silva VJ, Learsi SK, Araujo GG. Ingestion of a drink containing carbohydrate increases the number of bench press repetitions. Rev Nutr. 2019;32:e190056. http://dx.doi.org/10.1590/1678-9865201932e180056

Results

The ingestion of carbohydrate increases muscle resistance in relation to placebo (*p*=0.014; effect size=0.71). This is evidenced by the increase in the number of repetitions (12.9±2.4 and 11.3±1.9, respectively). The individual's perception of effort is higher in the carbohydrate group than in the placebo group after exhaustion (4±0.93 and 3.1±0.64, respectively, *p*=0.006, effect size=0.89).

Conclusion

It is concluded that a previous intake of carbohydrate is useful in improving performance in resistance exercises, providing an increase in the individual's perception of effort.

Keywords: Nutrition. Strength. Supplementation.

RESUMO

Objetivo

O presente estudo teve como objetivo verificar os efeitos da ingestão prévia de carboidrato no número de repetições durante o exercício supino reto em indivíduos praticantes de musculação.

Métodos

Oito participantes fisicamente ativos do sexo masculino (21,3±2,7 anos, 176±5cm, 73,12±6,12kg) com experiência mínima de um ano em treinamento de força visitaram o laboratório em três momentos. Durante a primeira visita foi realizada uma avaliação antropométrica e aplicação do teste de uma repetição máxima no exercício supino reto. Os testes experimentais foram realizados nas visitas dois e três em um modelo cross over e cego onde os participantes executaram o número máximo de repetições com uma intensidade de 70% de uma repetição máxima. Uma hora antes dos testes experimentais, de forma randômica, os participantes ingeriram uma solução contendo carboidrato ou placebo.

Resultados

A ingestão de carboidrato foi capaz de aumentar a resistência muscular em relação ao placebo (p=0.014; effect size=0.71), fato evidenciado pelo aumento no número de repetições (12,9±2,4 e 11,3±1,9, respectivamente). A percepção subjetiva de esforço foi maior no grupo carboidrato em relação ao grupo placebo após a exaustão (4±0,93 e 3,1±0,64, respectivamente p=0.006, effect size=0.89).

Conclusão

Concluímos que a ingestão prévia de carboidrato é útil em melhorar o desempenho em exercícios de resistência com aumento associado da percepção subjetiva de esforço.

Palavras-chave: *Nutrição. Força. Suplementação.*

INTRODUCTION

Strength training is part of the fitness program for athletes of various sports. It provides benefits such as increased muscle mass, strengthening of tendons and ligaments, increased protein synthesis, decreased fat percentage, disease prevention, and decreased risks of injury [1]. Thus, the chronic effects of strength training are associated with nutritional strategies, allowing better results in sports performance [2,3].

Among nutritional strategies, Carbohydrate (CHO) manipulation has been widely studied. It has been used as an ergogenic resource to improve performance in various sports [4-6]. Over the years, the effects of CHO on long-term exercise performance [7,8] and on high-intensity exercises [9] have become increasingly popular. An adequate CHO availability has been considered determinant and essential for effort in cycling events lasting 60, 90 and 120 minutes [10,11]. Regarding resistance exercises for the lower limbs, supplementation with CHO allows the number of repetitions of knee extension and flexion to increase in relation to *placebo* tests (PLA) [3,12,13]. The same effect occurs in resistance exercises for the upper limbs. Recently, an increase in the number of bench press repetitions was observed when 15g of CHO were ingested before exercising and approximately every 15min throughout the test (total~75g) [6].

The mechanism for such positive results is that pre-exercise supplementation increases glycemia and delays the onset of fatigue by promoting a higher rate of glucose oxidation. It also contributes to an increase in muscle glycogen content [9], or even in maintaining a Ratio Perceived Exertion (RPE) [14] by reducing the concentration of cortisol, a stress-related hormone, during exercise [15]. However, results related to CHO ingestion before resistance exercises are still conflicting. In some studies, there were no improvements in performance due to CHO ingestion [16-18]. In addition, only one study examined the effects of CHO supplementation on upper limb exercises [6].

In this context, this study aims to verify the effects of previous CHO ingestion on muscular resistance bench press exercises. The hypothesis is that CHO ingestion would decrease RPE and contribute to an increase in the number of bench press repetitions at an intensity of 70% of One Repetition Maximum (1RM).

METHODS

Eight male physically active (mean age: 21.3±2.7 years, weight: 73.1±6.1kg, height:176±5cm, Body Mass Index [BMI]:23.7±3.02kg/m², 1RM:66.8±13.5kg, 70% 1RM:46.7±9.4kg), who have been strength training athletes for at least one year, and have not used food supplements for at least one month before the study, were selected. The participants were instructed not to exercise the day before the experiment, nor to drink any alcoholic beverages, nor to ingest anything containing caffeine. Food prior to experimental testing was not controlled. However, in order to minimize any effects of the diet, participants were asked to repeat the same meal 24 hours before the first visit. All participants signed an informed consent term prior to the beginning of the tests. The procedures were approved by the Research Ethics Committee of the *Universidade Federal de Alagoas* (UFAL, Federal University of *Alagoas*) - protocol No.398054.

Experimental procedure

This is a blind, crossover, placebo-controlled, randomized study. The tests were performed at the *Laboratório de Ciências Aplicadas ao Esporte* (LACAE, Laboratory of Applied Sports Science). Each participant visited the laboratory at three different moments of the experiment. At the first visit, two tests were performed: an anthropometric evaluation and the 1RM test. Experimental tests, which consisted of performing the highest number of repetitions at a 70% intensity of 1RM after the ingestion of CHO or PLA, were conducted at the two subsequent visits, which were separated by 72-96hr.

1RM test

Participants performed a specific warm up session on the equipment which would be used in the test (Technogym®, Cesena, Italy) using a weight equivalent to 50% of the weight used for ten maximum repetitions during a regular training session. After the warm up session, individuals rested for five minutes. Then, one repetition was performed using 100% of the estimated 1RM. Load was added to the exercise (5%), and the participant was instructed to perform another repetition. If the participant was capable of performing more than one repetition, the load would be progressively increased in two kilograms for a maximum of five sets, with a three-minute interval between them. When the participant would not be able to carry out the whole movement, the load of the last execution would be validated as their maximum load. The weight of the bar was not included in the total weight. Obtaining the result of 1RM enabled the researchers to calculate the load equivalent to 70% 1RM [19].

Muscle resistance test

Muscle resistance was assessed using the equivalent load of 70% 1RM. The participants were instructed to perform the movements until voluntary exhaustion. The execution time of repetitions was controlled by a metronome (GMT200P SL Metro Tuner, China) with a frequency of 1:3 (repetition: seconds). The number of maximum repetitions was recorded. The RPE was recorded using the Borg scale (1-10) [20] according to the reports by the participant immediately at the end of each maximum repetition. The test ended when the participant did not meet the correct time to perform the movement for two consecutive times, or by voluntarily ending the test due to fatigue.

Ratio Perceived Exertion

The subjective perception of effort, created by Borg [20], was used as an instrument to quantify the sensation of effort generated during exercise. Even though it is a simple, non-invasive and cost-free indicator, the Ratio Perceived Exertion responds to the intensity of exercise, or more specifically to the stress on the cardiopulmonary and muscular systems. Prior to the start of the test, the same professional explained to the participant the purpose of the scale and at what times they would need to report on their perception of effort. The Borg Scale [20], from 1 to 10, was used. Each number represents a perceived effort level for each test stage. The selection of the number was performed verbally by the volunteers, immediately at the end of their maximum repetition.

Supplementation protocol

The CHO solution was composed of 20g of unflavored maltodextrin (Neonutri) dissolved into 200mL of water. As the solution's masking flavor, it was added a lemon-flavored non-energetic powder juice (7g, Clight®, Chicago, USA). The PLA solution consisted of the same non-energy juice used in the CHO solution diluted into 200mL of water. Both beverages had a similar flavor, smell and density, and were served cold, sixty minutes prior to the experimental tests.

Statistical analysis

Data were expressed as Mean±Standard Deviation (SD). To verify normality of data, the Shapiro-Wilk test was performed. The comparison between CHO and PLA groups was performed using the paired Student *t* test. The significance level was $p<0.05$. The effect size was calculated using the formula (mean PLA - mean CHO)/pooled Standard Deviation [21]. The data were analyzed using the Statistical Package for Social Sciences software, version 13.0 (SPSS Inc., Chicago, Illinois, United States).

RESULTS

The performance improved approximately by 15% for six of the eight participants after CHO ingestion (Figure 1A). In general, when participants ingested the drink containing CHO, they were able to perform a greater number of bench press repetitions when compared to the PLA group (12.9±2.4±11.3±1.9, respectively. *p*=0.014; effect size =0.71; Figure 1B).

The Ratio Perceived Exertion increased according to the number of repetitions performed. The values were higher in the CHO group in relation to the PLA group (4±0.93 and 3.1±0.64, respectively. *p*=0.006, effect size=0.89, Figure 2).

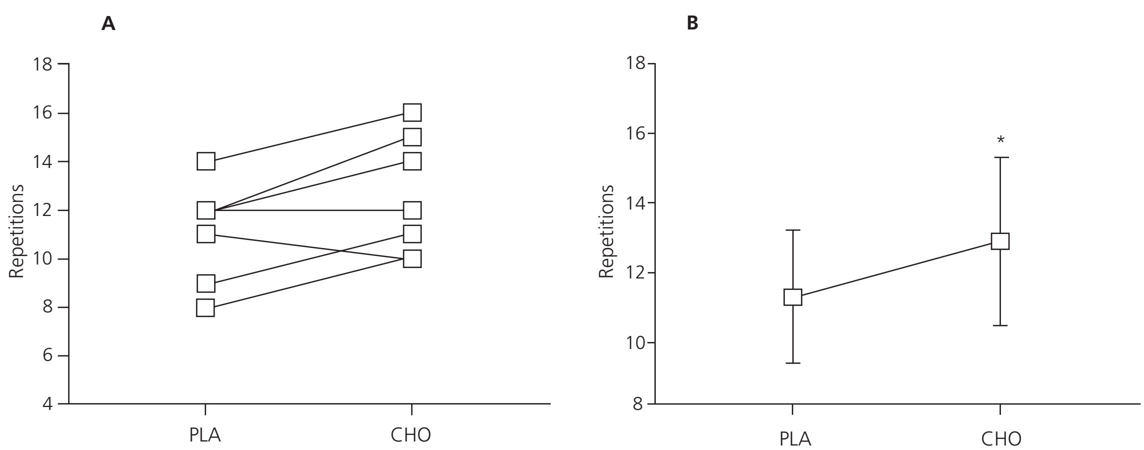

Figure 1. (A) Number of maximum individual bench press repetitions until exhaustion in the Placebo (PLA) and Carbohydrate (CHO) groups. (B) Mean and standard deviation of the number of replicates of the Placebo (PLA) and Carbohydrate (CHO) groups.

Note: *Higher than PLA (*p*=0.014; and effect *size*: 0.71).

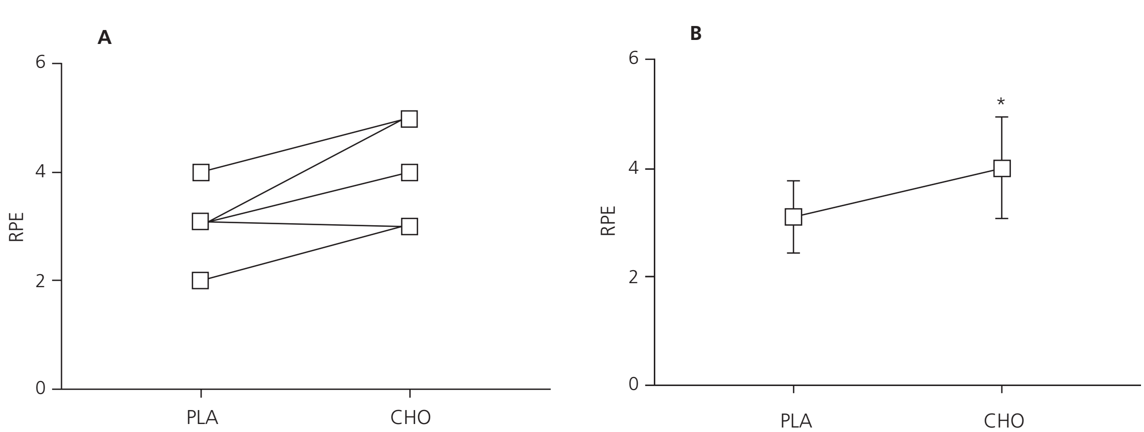

Figure 2. (A) Subjective perception of individual effort in the placebo (PLA) and carbohydrate (CHO) groups. (B) Mean and standard deviation of the subjective perception of effort of the Placebo (PLA) and Carbohydrate (CHO) groups.

Note: *Higher than PLA (*p*=0.006; and effect *size*: 0.89). RPE: Ratio Perceived Exertion.

 http://dx.doi.org/10.1590/1678-9865201932e180056

DISCUSSION

The ingestion of CHO before resistance exercises increased the number of repetitions when compared to the ingestion of PLA.This fact corroborates the initial hypothesis. However, the RPE increased in the CHO group, diverging from the hypothesis.

The increase in the number of repetitions is in accordance with previous studies. The ingestion of CHO immediately before the 80% 1RM strength training session increases the ability to perform sets and repetitions of knee extension exercises in relation to the ingestion of PLA [12,22]. The findings also corroborate the increase in the number of bench press repetitions after 15 minutes of ingestion of a drink containing CHO [6]. However, the results contrast with the findings of Haff *et al*. [17], who did not find differences in the number of repetitions in exercises for lower limbs after the ingestion of CHO. The methodological variations at the different times of CHO ingestion or the type of exercise performed may be a possible explanation for the divergence between the studies.

The first study to investigate the effects of a prior ingestion of CHO was conducted by Boje [23]. The author observed a decreased blood glucose level during exercise when CHO was ingested before it was performed. Similar results were reported by other studies, with a consequent impairment in performance when CHO was ingested prior to exercising [24,25]. However, over the years, the results of studies have been controversial. The intake of CHO (6.0%, 8mL/kg) 15min before an intermittent and high-intensity exercise contributed to improving performance [26].It also increased the average power, according to the Wingate test (22.0%, 1g.kg^{-1}) [27], and the time until exhaustion (6.4%) in a test at 90.0% Wmax after 30 minutes of ingestion [28]. Although there are studies reporting that ingesting CHO before exercise would lead to a worsening of performance by causing rebound hypoglycemia [29,30], it is important to note that some individuals are hypoglycemic, but others are not adversely affected when ingesting CHO before exercising [31]. Based on such individual response to CHO ingestion, a definitive conclusion about deleterious effects of CHO prior to exercising should not be made [30] because other studies [32,33] have observed a positive effect of CHO ingestion before exercising.

The beneficial effects of CHO supplementation may be due to several mechanisms such as (1) maintenance of glycemia, (2) increased muscle glycogen resynthesis, (3) central fatigue attenuation, among others [34,35]. The latter mechanism is associated with circulating levels of glucose that appear to be an important source of energy for the central nervous system [36]. Hypothetically, the CHO would delay central fatigue during exercise due to a decreased serotonin production [37]. Moreover, the reduction or maintenance of RPE is one of the main actions of CHO during a high-intensity exercise (above 75% VO2 max) [38]. This measurement is a response to the conscious interpretation of intensity of effort [39]. The increase in training volume was accompanied by a consequent increase in the RPE, since this variable is related to the efforts made during exercise [39]. Although some authors have observed that CHO ingestion minimized the increase in the RPE during prolonged and intermittent exercise sessions [38,40], in this study, the ingestion of CHO did not attenuate the RPE, corroborating with other authors, who did not find any significant differences between the ingestion of CHO and PLA [34,41]. However, the type of exercise analyzed in studies reporting that the RPE decreased or remained stable even with an increased intensity or duration of effort is predominantly aerobic [41,42]. In a resistance exercise, however, in which an effort close to the maximum is required at each repetition, the ingestion of CHO contributes to improving performance without reducing RPE [43]. Thus, the increase in the number of repetitions may be associated with an increase in the RPE. The ingestion of CHO was not able to attenuate or decrease the RPE in resistance exercises.

In conclusion, the results found in this study evidence that the ingestion of CHO before a series of resistance training is efficient to increase the number of repetitions at 70% 1RM without reducing the RPE.

CONTRIBUTORS

MPP SANTOS Interpretation, analysis of data and writing. H SPINELI Interpretation, analysis of data and writing. VJ BASTOS-SILVA Interpretation, analysis of data and revision SK LEARSI Interpretation, analysis of data, and writing. GG ARAUJO study's concept and design, revision and data analysis.

ACKNOWLEDGMENTS

We would like to thank Tiago Muritiba da Silva for his contribution in data collection. The authors declare no conflicts of interest which are directly relevant to the contents of this study. This study was financed in part by the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil* (Capes) - Finance Code 001.

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Received: March 27, 2018
Final version: February 22, 2019
Approved: March 26, 2019