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Research Article

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The Effect of Acute Carbohydrate Ingestion on Strength Training Performance: A Systematic Review

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Abstract

Background: *The carbohydrates (CHO) ingestion may enhance performance in endurance sports because it is the nutrient that generates the fastest energy for the body, preferred at moderate to high intensities. This energy is also generated through muscle glycogen storage and even knowing that the glycogen depletion could limit endurance performance, the low pre-exercise glycogen availability may not significantly affect the efficiency strength training. However, this systematic review came to examines whether carbohydrate intake influences acute-term strength training performance.*

Methods: *The present systematic review followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The literature search was conducted in EBSCOhost within the MEDLINE and SPORTDiscus databases. Search terms included a combination of Medical Subject Headings (MeSH terms) and free-test words consisting of the following keywords: "(MH "Carbohydrates") OR ("glycogen depletion" OR "high carbohydrate" OR "low carbohydrate") AND MH "Resistance Training" OR MH "Weight Lift*" OR (isokinetic OR "strength training" OR "resistance training" OR "resistance exercise) AND (MH "Muscle Strength").*

Results: *After the searches, the author found a total of 1768 records. Of this total, 389 articles were selected, and 19 studies were included because they met all the inclusion and exclusion criteria mentioned in the methodology of this work. In total, 11 of the 19 acute studies found no significant effect of carbohydrate intake on strength training performance, this way, eight studies demonstrated statistical significance for the use of carbohydrates acutely before strength training, six favored the higher-carbohydrate condition and five studies reported more repetitions to failure/training volume.*

Conclusion: *According to the systematic analyzes carried out in this work, most studies show that the use of carbohydrates before strength tests is favorable to increased performance.*

Keywords: *Strength Training; Performance; Carbohydrates ingestion.*

Introduction

The carbohydrates (CHO) ingestion may enhance performance in endurance sports because it is the nutrient that generates the fastest energy for the body, preferred at moderate to high intensities [1]. This energy is also generated through muscle glycogen storage and even knowing that the glycogen depletion could limit endurance performance, the low pre-exercise glycogen availability may not significantly affect the efficiency strength training [2]. To avoid this problem, the general recommendations are 6 to 12 g. kg^{-1}. day^{-1} for athletes [1], but for the bodybuilders athletes these recommendations can be to range from 2.8 to 7.5 g. kg^{-1}. day^{-1} and to 4.2 to 8 g. kg^{-1}. day^{-1} in strength-athletes [3]. However, this systematic review came to examines whether carbohydrate intake influences acute-term strength training performance.

Methods

The present systematic review followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [4]. The literature search was conducted in EBSCOhost within the MEDLINE and SPORTDiscus databases. Search terms included a combination of Medical Subject Headings (MeSH terms) and free-test words consisting of the following keywords: "(MH "Carbohydrates") OR ("glycogen depletion" OR "high carbohydrate" OR "low carbohydrate") AND MH "Resistance Training" OR MH "Weight Lift*" OR (isokinetic OR "strength training" OR "resistance training" OR "resistance exercise) AND (MH "Muscle Strength"). Online published trials were included if measured dynamic resistance training performance as an outcome, this way the studies were categorized as either acute carbohydrate manipulation (up to 24 h) or supplementation prior to strength tests. Besides that, all participants on these studies had to be healthy (i.e., free of chronic diseases) and below 60 years of age. Papers in all languages were eligible. Letters were not included.

Results

After the searches, the author found a total of 1768 records. Of this total, 389 articles were selected, and 19 studies were included because they met all the inclusion and exclusion criteria mentioned in the methodology of this work. In total, 11 of the 19 acute studies found no significant effect of carbohydrate intake on strength training performance, this way, eight studies demonstrated statistical significance for the use of carbohydrates acutely before strength training, six favored the higher-carbohydrate condition and five studies reported more repetitions to failure/training volume. However, none of the isocaloric comparisons found the higher carbohydrate condition had greater performance than the lower carbohydrate condition.

But positive effects of carbohydrate intake were more prevalent when compared to fasts of four or more hours, but the effect of fasting duration was not clear. At the studies comparing carbohydrate intake to an overnight fasted state, positive findings of carbohydrate intake compared to fasting are not necessarily indicative of a metabolic advantage of carbohydrate consumption. In summary, eleven studies showed no effect on carbohydrate intake and improved performance in strength tests, six were in favor of carbohydrate consumption before strength tests and two were in favor of placebo consumption for improved strength on these tests. The data discussed in this section are systematically displayed in table 1.

Table 1. The acute effect of carbohydrate ingestion on strength training performance.

Study	Design	Carbohydrate intake	Results
[5]	RCT (n = 32)	CHO: 0.59 g. kg^{-1} Timing: 355 mL 30 min prior to exercise.	No significant differences between conditions.
[6]	RCT (n = 22)	CHO: 1 g. kg^{-1} beverage supplement. Placebo: non-caloric supplement. Control: no supplement. Timing: 30 min before testing.	No significant differences in repetitions to failure between conditions.
[7]	Counterbal anced crossover (n = 17)	CHO: 1.1 g. kg^{-1} (75 g). Placebo: non-caloric supplement. Timing: after the first baseline 3 RM.	There was no interaction effect but when adjusting for baseline values a significant main effect between conditions were observed were the CHO condition.
[8]	Crossover (n = 8)	CHO: 1 g. kg^{-1} (84 g) of maltodextrin beverage supplement. Placebo: non-caloric supplement. Timing: 15 min before training.	No significant differences in total training volume between conditions.
[9]	Crossover (n = 8)	CHO: 1.0 g. kg^{-1} prior to exercise and 0.51 g/kg during exercise (143 g in total). Placebo: non-caloric. Timing: before exercise and after set 1, 6 and 11.	No differences were observed between conditions in peak torque in the knee extension or any of the measurements for the knee flexors.
[10]	Crossover (n = 7).	CHOs: 15, 30 or 60 g. h^{-1} In addition to 5.5 g amino acids (AA) and electrolytes. Placebo: 5.5 g AA and electrolytes. Timing: before exercise and every 15 min during exercise, total 5 dosages.	No significant differences for the other three exercises, two jumps or four run times, except 60 g/h > placebo for the 27-m sprint.
[11]	Counterbal anced crossover (n = 8)	CHO: 0.3 g. kg^{-1} (28 g). Placebo: non-caloric. Timing: before and after every other set of 5 repetitions.	No significant differences between conditions in repetitions and sets to failure or volume load and total load.
[12]	Crossover (n = 7).	CHO: 1 g. kg^{-1} before exercise and 0.17 g. kg^{-1} dosages during exercise (97 or 125 g in total). Placebo: non-caloric. Timing: before exercise, an after set 5, 10 and 15.	No significant difference in repetitions and sets to failure between the conditions.
[13]	Crossover (n = 10).	CHO: 0.43 g. kg^{-1} (36 g and 12 g of protein). Placebo: non-caloric. Timing: two dosages, 12 and 26 min into exercise.	Significantly more total bench press volume in the CHO condition.
[14]	Crossover (n = 15)	CHO: A total of 0.84 g. kg^{-1} (68 g). High-protein: 40 g protein, 11 g of carbohydrate and 6 g fat (isocaloric to CHO). Timing: within 5 min of completing the first workout.	No significant difference between conditions in agility T-test, push-ups to failure or sprint.
[15]	Crossover (n = 8)	CHO-protein (ratio 3:1): 67.5 g CHO and 22.5 g protein. CHO-protein (ratio 2:2): 45 g CHO and 45 g protein. Placebo: non-caloric. Timing: 1 h and immediately before testing.	No significant difference between conditions in repetitions to failure.

[16]	Counterbalanced (n = 16)	CHO: A total of 1.5 g. kg^{-1} (116 g), standardized breakfast meal, ~20% of estimated energy needs. Control: water only. Timing: 2 h before testing.	Significantly more repetitions to failure in the CHO condition for squat and bench press.
[17]	Counterbalanced (n = 22)	CHO: A total of 1.5 g. kg^{-1} (117 g), standardized breakfast meal, 496 kcal. Placebo: semi-solid, 29 kcal with low-energy flavored squash and water. Control: water only. Timing: ~2 h before testing.	Significantly more repetitions to failure in the CHO and placebo breakfast conditions in the squat exercise.
[18]	Counterbalanced (n = 13)	CHO: A total of 1 g. kg^{-1} (81 g). Placebo: non-caloric. Timing: A total of 1 h before exercise.	No significant differences between conditions in repetitions to failure and training volume.
[19]	Crossover (n = 8)	CHO: A total of 0.2 g. kg^{-1} (16 g). Placebo: non-caloric. Timing: before exercise and during the training session (6 total dosages of 2.7 g each).	No significant differences between conditions in repetitions to failure.
[20]	Crossover (n = 8)	CHO: A total of 0.27 g. kg^{-1} (20 g). Placebo: non-caloric. Timing: 1 h before training.	Significantly more repetitions in the CHO condition.
[21]	Crossover (n = 13)	CHO: A total of 0.44 g. kg^{-1} (36 g). Placebo: non-caloric. Timing: the total dosage was distributed to be ingested before and after warm-up, and after the last set of each exercise.	No significant time x treatment interactions for any exercise for repetition performance.
[22]	RCT (n = 27)	CHO: A total of 0.81 g. kg^{-1} (~60 g), 0 g PRO CHO-PRO: A total of 0.65 g. kg^{-1} (~50 g) CHO, ~14 g PRO Placebo: non-caloric (15 kcal) Timing: A total of 15 min before training (~30 g) and between every other set (in total ~30 g).	Significantly more repetitions in the CHO and CHO-PRO condition.
[23]	Crossover (n = 10)	CHO: A total of 2 g. kg^{-1} (180 g). Placebo: non-caloric. Timing: 30 min before training.	No significant differences between conditions.

Conclusion

According to the systematic analyzes carried out in this work, most studies show that the use of carbohydrates before strength tests is favorable to increased performance. Larger studies, such as meta-analyses that include other systematic reviews on the same topic, are needed to elucidate all the gaps that arise from this conclusion.

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