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Original article

Effects of protein addition to carbohydrate−electrolyte solutions on postexercise rehydration

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Abstract

Background/Objective: This study aimed to examine the effects of the addition of whey or casein protein, the two major proteins in milk, to carbohydrate−electrolyte (CE) solutions on postexercise rehydration.
Methods: Ten young men aged 20.7 ± 1.4 years with an average VO_{2max} of 60.7 mL/kg/min ran for 60 minutes at 65% VO_{2max} on three occasions followed by 4 hours' recovery. During recovery, the participants consumed either CE solution with 66 g/L carbohydrate (CHO), or CE plus whey protein solution (CW trial, 44 g/L CHO, 22 g/L whey), or CE plus casein protein solution (CC trial, 44 g/L CHO, 22 g/L casein); the solutions were matched for energy and electrolyte content.
Results: The participants lost 2.36 ± 0.32% of their pre-exercise body weight after the exercise. Total urine output after recovery was greater in the CE and CC trials than CW trial (CE vs. CW vs. CC: 1184 ± 378 mL vs. 1005 ± 214 mL vs. 1256 ± 413 mL; $p < 0.05$). Fluid retention after ingestion of CW solution was greater than CE and CC solutions (CE vs. CW vs. CC: 46.9 ± 16.5% vs. 54.9 ± 9.2% vs. 45.8 ± 17.3%; $p < 0.05$). Lower urine specific gravity and urine osmolality were observed by the end of recovery in the CE trial compared with CW trial ($p < 0.05$). No difference was found in the changes in plasma volume in all trials.
Conclusion: These results suggest that during the 4 hours' recovery after a 60-minute run, the CW solution was more effective for rehydration compared with the CE or CC solution.

Keywords: Carbohydrate−electrolyte solutions; Casein protein; Rehydration; Whey protein

Introduction

Prolonged endurance exercise is known to induce dehydration because of sweat loss. Besides water, some electrolytes such as sodium are also lost.[1] If the recovery time is limited (< 12 hours), effective rehydration strategies are generally recommended for a swift recovery after exercise.[2−4] It is recommended that athletes should drink a volume equal to 150% of their body weight (BW) loss during recovery,[4,5] and the rehydration solution should contain a certain amount of sodium and potassium because they can replace the major electrolytes loss in sweat.[6−8] Commercial sports drinks that contain water, carbohydrates (CHOs), and electrolytes are helpful for postexercise rehydration as reported in previous studies.[9,10]

Recently, it was reported that the low-fat milk is more helpful in fluid retention than common carbohydrate−electrolyte (CE) solutions.[11,12] Milk naturally contains as high a content of CHO and electrolytes as CE solutions, the

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specific element of milk protein may have some additional effects on fluid retention. However, the potential specific effects of milk protein cannot be illustrated because the low-fat milk and CE solutions in previous studies were not matched for the compositions.

Several studies have demonstrated that the ingestion of solutions containing protein after exercise is also better than that of CE solutions.[13–15] Seifert et al[15] reported that the addition of protein to a traditional sports drink improves water retention in the body. But the participants drank a volume equal to their BW loss and the drinks were not matched for energy density and electrolyte concentration. In more recent studies, James et al[13,14] found that the addition of milk protein to a CE solution is more effective in postexercise rehydration than a CE solution alone if the two solutions are matched for energy density and electrolyte concentration.

As is known, two protein groups exist in milk or milk protein. One of the protein groups is whey protein, which accounts for about 20% of the total protein in milk. Another protein group is named casein protein and accounts for the remaining 80% of the total protein in milk.[16] Whey protein is defined as "fast protein" because it can empty from the stomach and be absorbed by the intestine rapidly. By contrast, casein protein is known as "slow protein" because it coagulates when mixed with the gastric acids in stomach, by which the stomach emptying rate will be delayed.[17] Even the contents of total amino acids (AAs) and essential AAs are similar in both whey and casein protein groups, the blood AA concentration is reported to be greater after consumption of whey protein than casein protein.[18,19] It is interesting to know which protein group plays the major role in fluid retention when milk or milk protein was consumed by participants. Moreover, whether these two types of protein have different effects on postexercise rehydration remains unclear. The purpose of this study was therefore to examine the effects of the addition of whey or casein protein to CE solutions on postexercise rehydration.

Methods

Participants

Ten healthy men [age, 20.7 ± 1.4 years; BW, 65.4 ± 6.3 kg; maximal oxygen uptake (VO_{2max}), 60.7 ± 6.1 mL/kg/min] volunteered to participate in this study. They were all runners in the school team but not experienced athletes. The medical history of all participants was surveyed prior to participation. Written informed consent was obtained from all participants after the details and procedures of the experiment were fully explained. The protocols were approved by the University Clinical Research Ethical Committee of The Chinese University of Hong Kong.

Preliminary test

Participants were asked to complete a preliminary test followed by three main experimental trials. During the preliminary test, participants underwent an incremental submaximal running test to determine the relationship between running speed and oxygen uptake (VO_2). The test comprised four stages, with each stage lasting for 4 minutes. The participants began running on the treadmill at 7 km/h in the first stage, which gradually increased by 1.5 km/h in each stage. Therefore, the running speed in the fourth stage reached 11.5 km/h. Expired gas was collected and analyzed during the last minute of each stage. The running speed and VO_2 value were recorded in each stage throughout the test, so in total there were four coordinate values of these two variables, respectively. Then the relationship between the running speed and VO_2 of each volunteer was calculated by linearly regressing the four coordinate values of these two variables. VO_{2max} of each participant was then determined during uphill, incremental treadmill running to volitional exhaustion as described in the existing literature.[20] In the main trial tests, participants were asked to run at a speed that elicited 65% of their VO_{2max}.

Experimental protocol

Three main experimental trials were conducted in a randomized crossover manner. Trials were separated by at least 7 days. All the trials were conducted in an exercise physiology laboratory at similar environmental conditions (temperature: 24°C; relative humidity: 65%). The participants were asked to record their dietary intake and physical activity details 24 hours prior to the first trial. The recorded dietary intake and physical activity patterns were repeated in the other two trials. Participants were also asked to refrain from any strenuous exercise and alcohol consumption for 24 hours prior to each trial.

Experimental trials began early in the morning after overnight fasting (10–12 hours). Upon arrival at the laboratory, participants consumed 500 mL of plain water and rested for 1 hour. This step was performed to ensure that the participants were in a euhydrated state at the beginning of the experiment. The participants were asked to empty their bladders prior to each trial, and urine samples were collected. Nude BW was measured to the nearest 100 g (TBF-531A; TANITA Body Fat Monitor, TANITA Health, Tokyo, Japan). After 10 minutes of rest in a sitting position, the baseline capillary blood samples were obtained from the finger.

The participants began to run on a treadmill at 65% of their VO_{2max} for 60 minutes after a 10-minute warm-up. Running speed was determined by the aforementioned preliminary test. Expired gas and ratings of perceived exertion[21] were obtained every 20 minutes during the 60 minutes run. Heart rate (HR) was measured using a HR monitor (Sport Tester PE 4000; Polar Electro, Kempele, Finland). The participants consumed no fluid during the 60-minute run.

Urine and capillary blood samples were immediately collected after the 60-minute run. The participants were then allowed to have a 15-minute shower, after which nude BW was measured again. Postexercise BW was compared with pre-exercise BW to calculate BW loss. A total of 4 hours' recovery period ensued after data collection. During recovery, one of the three following solutions was consumed: (1) CE,