Effect of Carbohydrate Ingestion on the Glycemic Response of Type 1 Diabetic Adolescents During Exercise

CLAUDIA PERRONE, MSc1,2
ORLANDO LAITANO, BSc1
FLÁVIA MEYER, PhD1

Ingestion of a drink containing sufficient carbohydrates can result in avoidance of exercise-induced hypoglycemia in type 1 diabetic individuals. In a previous study (1), we analyzed the effect of ingesting a drink with 6% carbohydrate (0.636 g/kg) on blood glucose concentration in type 1 diabetic adolescents during 60 min of moderate exercise and after 30 min of recovery. At the end of the trial, blood glucose concentration was reduced by 21 mg/dl.

Both drinks were prepared by adding glucose and fructose to a solution with 4% sucrose and 2% fructose (Gatorade). The 8 and 10% carbohydrate drinks contained (in 100 ml) 5.38 and 6.72 g glucose and 2.62 and 3.28 g fructose, respectively. The volume ingested was the same in both trials and was calculated according to the subject’s maturity (3). Both drinks had the same grape flavor and color and were offered in randomized order and with a double-blind design. Drink acceptance and gastrointestinal symptoms were evaluated using a five-level category scale questionnaire.

All subjects were first screened and then submitted to two trials. Screening consisted of evaluation of health status, physical activity, weight, height, and maximal oxygen consumption (VO2max). To standardize exercise intensity in the trials, VO2max (Medgraphics model CPX/D) was determined by a continuous McMaster protocol (4) in a cycle ergometer. Intensity was increased every 2 min according to subject height.

Other than the drink ingested, the trials were identical and conducted from 4 to 7 days apart and at the same time of day, ~3 h after insulin administration, which was instructed to be injected in the abdomen (5). Subjects were asked to maintain their regular eating habits and medication.

In both trials, subjects cycled for 60 min at 55–60% of their predetermined VO2max at room temperature (20–22°C). Heart rate was monitored (Polar Electro), and subjects were asked to report their rate of perceived exertion every 15 min according to the Borg scale (6).

Capillary glucose concentration (Accu-Check Advantage II) was measured before exercise, every 15 min during exercise, and 30 and 60 min after exercise (recovery period). Exercise was interrupted whenever blood glucose concentration reached 60 mg/dl (7). Four subjects interrupted the 8% carbohydrate trial and were excluded.

Venous blood was collected from the forearm 15 min before and 5 min after the exercise period, and glucose levels were determined by an enzymatic method (hexokinase glucose).

Data are presented as means ± SD. Repeated-measures ANOVA and two-tailed t test were used to compare trials. P < 0.05 was considered significant.

RESULTS — The average drink volume ingested during the trials was 666 ± 92.0 ml; this was sufficient to maintain subjects in euhydration. Pre- and postexercise body mass were 60.7 ± 8.2 and 60.7 ± 8.15 kg (P = 0.587), respectively, with the 8% carbohydrate drink and 60.9 ± 8.5 and 60.9 ± 8.4 kg (P = 0.591), respectively, with the 10% carbohydrate drink. The mean ingestion with the 8% carbohydrate drink was 53.3 g carbohydrate (17.6 g fructose and 35.7 g glucose). In the 10% carbohydrate drink, the mean carbohydrate amount was 66.5 g (21.9 g fructose and 44.6 g glucose).

None of the subjects presented gastrointestinal symptoms. On the drink acceptance questionnaire, 87.5% answered from “very good” to “good” and 12.5% indicated “indifferent.”

Figure 1 shows capillary glucose concentrations. No changes were found in capillary glucose concentration during the 8 and 10% carbohydrate trials. Also, venous blood glucose pre- and postexercise did not differ. By the end of exercise, the difference of blood glucose concentration between drinks was 36.8 ± 60 mg/dl (P = 0.033). During recovery, capillary glucose concentration showed a drop of 31.4 ± 26.2 mg/dl (P = 0.002) in the 8% carbohydrate trial and no changes in the
10% carbohydrate trial. By the end of recovery, the blood glucose concentration between trials was similar. The changes in venous glucose concentration during the recovery period were similar to the capillary changes. A decrease of 29.2 ± 24.0 mg/dl (P = 0.006) was observed in the 8% carbohydrate trial, and no change was found in the 10% carbohydrate trial.

From the beginning of the exercise until the end of recovery, capillary glucose concentration showed a reduction of 42.3 ± 43.1 mg/dl (P = 0.006) in the 8% carbohydrate trial. No change was found in the 10% carbohydrate trial. No difference was observed between drinks. The venous glucose concentration from pre-exercise to recovery occurred in a similar way. There was no reduction with the ingestion of the 8 and 10% carbohydrate drinks. The difference between both drinks was not significant (P = 0.065). Capillary and venous glucose concentrations were highly correlated (r = 0.98, P < 0.001).

Heart rate responses during exercise showed a significant increase of 21.0 ± 16.4 bpm (P < 0.05) with the 8% carbohydrate trial and 24.0 ± 17 bpm (P < 0.05) with the 10% carbohydrate trial, but without a difference between situations at any of the stages (P = 0.118). The rate of perceived exertion values was similar in both trials, ranging from 12 to 13 ("somewhat hard").

CONCLUSIONS — Supplementation of 8 and 10% carbohydrate drinks, ingested before and during exercise, was, in most cases, enough to maintain the blood glucose concentration in type 1 diabetic adolescents. Since four subjects interrupted exercise during the 8% carbohydrate trial due to a drop in blood glucose concentration, the ingestion of 10% carbohydrate drinks could be recommended to avoid exercise-induced hypoglycemia. In addition, the drinks did not cause any gastrointestinal symptoms and kept the individuals euhydrated.

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References