Supplementary effect of carbohydrate-electrolyte drink on sports performance, lactate removal & cardiovascular...
Supplementary effect of carbohydrate-electrolyte drink on sports performance, lactate removal & cardiovascular response of athletes

G.L. Khanna & I. Manna*

Human Performance Laboratory, Sports Authority of India, New Delhi, India

Received May 19, 2004

Background & objectives: Carbohydrate-electrolyte drink has a significant role on energy balance during exercise. The present study was designed to investigate the effect of oral carbohydrate-electrolyte supplementation on sports performance and cardiovascular status of the national level male athletes during exercise and recovery.

Methods: A total of 10 male athletes (age range: 20-25 yr) were selected. The experiment was performed in laboratory (25°C and 60% relative humidity) in two phases; phase 1 - no supplementation, and phase 2 - a 5 g per cent carbohydrate-electrolyte drink was given orally during exercise and a 12.5 g per cent carbohydrate-electrolyte drink during recovery. Subjects performed an exercise test at 70 per cent of VO₂max. Performance time, heart rate during exercise and recovery were noted, blood samples were collected during exercise and recovery for the analysis of glucose and lactate levels in both the phases.

Results: Significant improvements were noted in total endurance time, heart rate responses and blood lactate during exercise at 70 per cent VO₂max after the supplementation of 5 g per cent carbohydrate-electrolyte drink. However, no significant changes were noted in blood glucose and peak lactate level irrespective of supplementation of carbohydrate-electrolyte drink. Significant improvement in cardiovascular responses, blood glucose and lactate removal were noted during recovery following a 12.5 g per cent carbohydrate-electrolyte drink.

Interpretation & conclusion: Carbohydrate-electrolyte drink can increase endurance performance as well as enhance lactate removal and thereby delaying the onset of fatigue.

Key words Carbohydrate - electrolyte - exercise - glucose - heart rate - lactate

Loss of fluid electrolyte and reduction of the body’s carbohydrate stores are the major causes of fatigue in prolonged exhaustive exercise1-3. Dehydration resulting from sweat loss, and increase in core temperature may be primary cause of fatigue even in moderate climatic conditions4,5. Though sweat loss in high intensity, short duration exercise is small, exercise capacity is impaired if there is a pre-exercise fluid
deficit. Fluid ingestion during exercise has the twin benefits of providing a source of carbohydrate fluid to supplement the body's limited store, and of supplying water to replace losses caused by sweating\textsuperscript{6,7}. Several studies have indicated that carbohydrate supplementation during prolonged exercise improves endurance performance by maintaining blood glucose levels\textsuperscript{8,9}. Electrolyte content of the fluid maintains the electrolyte balance and reduces the onset of fatigue\textsuperscript{10-13}.

Though many studies has been performed worldwide in this area, studies from India are limited. We carried out this study to find out the effect of carbohydrate-electrolyte drink on endurance performance and cardiovascular status during exercise and recovery in male Indian athletes playing at national level.

**Material & Methods**

**Subjects and supplementation:** The study was conducted at Bangalore in the month of October 2001 in the Sports Authority of India. A total of 16 male endurance athletes (age range 20-25 yr) participated at National level were selected after thorough medical examination. Four athletes left the study in between and two got injured during practice session. Study could be completed with ten subjects only. The subjects were given a detailed description of the procedure and potential complications. The physical and physiological characteristics of the athletes were recorded (Table I). Participants were advised not to engage in strenuous activities two days before an exercise test and not to exercise on the day of the test. They were requested to maintain their normal diet and to refrain from alcohol and caffeinated beverage in the week preceding the experiment and throughout the experiment.

The experiment was performed in two phases: in the first phase no supplementation was given, whereas, in the second phase a 100 ml of 5 g per cent carbohydrate-electrolyte drink (carbohydrate 5 g, sodium 9.2 mg, potassium 13.6 mg) was supplied during exercise at an interval of 15 min till exhaustion, and another 100 ml of 12.5 g per cent carbohydrate-electrolyte drink (carbohydrate 12.4 g, sodium 24.5 mg, potassium 34.1 mg) was given after 5 min of recovery and thereafter at an interval of 5 min up to 20 min. Heart rate and performance time were recorded. Blood samples were collected during exercise and recovery for analysis of blood glucose and lactate. Each test was scheduled at a similar time of day (±1 h) with a room temperature of 25±2°C, 60 per cent relative humidity in order to minimize the effect of diurnal fluctuation. All the parameters were measured before and after the supplementation. The Sports Authority of India approved the study and the procedures followed were in accord with the ethical standards on human experimentation (as per the guidelines laid down by the Central Ethical Committee of the Indian Council of Medical Research)\textsuperscript{14}.

**Exercise test:** One week prior to experimental testing, each subject’s maximum oxygen capacity (VO$_2$ max) was determined following standard methodology\textsuperscript{15}. The subject was asked to run on the treadmill (Jaeger LE 6000, Germany) at a speed of 6 km/h for 2 min thereafter, the workload was increased by 2 km/h for every 2 min until volitional exhaustion. Expired gas was collected and measured from a mixing chamber using Oxycon Champion (Jaeger, Germany). Evaluation of endurance performance and cardiovascular status were performed at 70 per cent of their maximum aerobic capacity using treadmill during two phases of experiment. Heart rate was monitored during exercise and recovery using sports testers (PE-3000, Finland). The maximum running

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values (mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>25.8 ± 2.4</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>167.2 ± 7.0</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>58.7 ± 8.5</td>
</tr>
<tr>
<td>VO$_2$ max (l/min)</td>
<td>3.2 ± 0.6</td>
</tr>
<tr>
<td>Relative VO$_2$ max (ml/kg/min)</td>
<td>54.4 ± 4.4</td>
</tr>
<tr>
<td>70% of VO$_2$ max (ml/kg/min)</td>
<td>38.1 ± 3.1</td>
</tr>
<tr>
<td>Maximum heart rate (bpm)</td>
<td>193.2 ± 6.6</td>
</tr>
<tr>
<td>Heart rate at 70% of VO$_2$ max (bpm)</td>
<td>159.3 ± 4.7</td>
</tr>
<tr>
<td>Oxygen pulse (ml/beat)</td>
<td>18.1 ± 2.3</td>
</tr>
<tr>
<td>Ventilatory equivalent (l/l of O$_2$)</td>
<td>35.1 ± 2.7</td>
</tr>
</tbody>
</table>
time till voluntary exhaustion was taken with a stopwatch (Sports Testers PE-3000, Finland). All the above parameters were measured during first and second phases of experiment with a gap of one week.

**Estimation of blood glucose and lactate:** Blood samples were collected at an interval of 10 min during exercise and recovery from fingertips for estimation of blood glucose$^{16}$ by spectrophotometric method (Hitachi U-2000 Spectrophotometer, Japan) using Boehringer Manheim kit, and lactate$^{17}$ by lactate analyzer (Analox P-LM55, UK) using Analox lactate kit supplied by Analox (UK) during exercise and recovery.

**Statistical analysis:** Wilcoxon signed rank test was applied for finding the significant difference between paired observations of single group. Two way repeated measure ANOVA was applied to find the effect of carbohydrate-electrolyte supplementation on endurance performance and recovery$^{18}$. All the statistical analysis were performed using SPSS for Windows 10.0 (SPSS Inc., USA).

**Results & Discussion**

**Effect of carbohydrate-electrolyte drink on endurance time and cardiovascular response during exercise and recovery:** Total time of endurance at 70 per cent VO$_2$ max was found to increase significantly ($P<0.01$) following a 5 g per cent carbohydrate-electrolyte drink supplement. The increase of total endurance time was noted about 51 per cent when supplied with carbohydrate-electrolyte drink. The endurance time recorded with and without carbohydrate-electrolyte drink supplement was 94.1±17.7 and 62.3±10.4 min respectively. Significant improvements in cardiovascular responses were noted during moderate intensity exercise (at 70% VO$_2$ max) following a 5 g per cent carbohydrate-electrolyte drink (Fig.). Cardiovascular responses during recovery were also improved significantly after the supplementation of 12.5 g per cent carbohydrate-electrolyte drink (Table II).

**Effect of carbohydrate-electrolyte drink on blood glucose levels during exercise and recovery:** Blood glucose values were noted at rest and then at an interval of 10 min each during exercise and recovery. No significant changes were noted in blood glucose level throughout the exercise period at 70 per cent VO$_2$ max when supplied with 5 g per cent carbohydrate-electrolyte drink. No significant change in blood glucose level was noted during recovery after 10 min (without supplementation 100.8±9.2 mg/dl; with supplementation 108.4±25.6 mg/dl), however, a significantly ($P<0.01$) higher blood glucose level was noted during recovery after 20 min (without supplementation 100.3±9.9 mg/dl; with supplementation 119.2±10.3 mg/dl) with a 12.5 g per cent carbohydrate-electrolyte drink.

**Effect of carbohydrate-electrolyte drink on blood lactate levels during exercise and recovery:** Blood lactate values were noted at rest and then at an interval of 10 min each during exercise and recovery. It was noted that supplementation of 5 g per cent carbohydrate-electrolyte drink keeps the blood lactate at lower levels. Although most of the values were not
significant, but significantly lower ($P<0.01$) value was noted after 70 min of exercise (without supplementation $3.4\pm0.6$ mmol/l compared to $2.1\pm0.4$ mmol/l with supplementation). However, no significant alteration was noted in peak lactate level (without supplementation $3.7\pm1.2$ mmol/l with supplementation $3.2\pm1.0$ mmol/l). Removal of blood lactate was significantly ($P<0.05$) faster after 10 min (without supplementation $3.1\pm1.0$ mmol/l; with supplementation $2.1\pm0.8$ mmol/l) and 20 min (without supplementation $2.5 \pm 0.9$ mmol/l; with supplementation $1.5\pm0.4$ mmol/l) with 12.5 g per cent carbohydrate-electrolyte drink.

Hypohydration impairs the body’s ability to regulate heat resulting in increased body temperature and an elevated heart rate, causing the athlete to feel more fatigued than usual at a given work rate with reduced mental function, followed by slow gastric emptying which results in stomach discomfort. All these effects lead to impairment in exercise performance. There is substantial evidence that consumption of an isotonic sports drink during exercise can improve performance during prolonged sub-maximal, intermittent, high intensity, and shuttle running test. The consumption of isotonic sports drinks either throughout or late in exercise has been shown to delay the onset of tiredness and thus improve performance. It may be either due to carbohydrate ingestion preventing a decline in blood glucose and maintaining carbohydrate oxidation at a high rate late in exercise, or due to muscle glycogen sparing early in exercise. The amount of pre-exercise muscle glycogen stores is an important factor in determining endurance capacity. Prolonged exercise causes dehydration and reduces the body’s carbohydrate energy stores. These are the major contributors to the onset of fatigue.

Different mechanisms have been proposed to show that the ergogenic effect of carbohydrate does not affect muscle glycogen at a critical point in endurance exercise when liver and muscle glycogen levels are low and uptake of glycogen by skeletal muscle is increased. The carbohydrate content of drinks taken should be determined by relative needs to supply fuel and water. This depends on the intensity and duration of the exercise, the ambient temperature and humidity, and on the physiological and biochemical characteristics of the individual athlete. Electrolytes of sodium, magnesium, calcium and potassium help the cells to function normally and provide the key to muscle function, mental focus and body cooling. Electrolytes are easily lost in sweat and urine during physical activity, so replenishing these minerals is important. More severe water loss at high temperatures along with electrolytes puts a person at risk of heat cramps or sometimes heat stroke. Low level of potassium or magnesium enhances muscles cramp.

Optimal post-exercise rehydration requires both higher fluid volume replacement and sodium content compared with rehydration during exercise. Ingestion of plain water delays rehydration because it decreases plasma osmolality, reduces thirst and increases free-water clearance. Replacement of sodium lost in sweat is important in maximizing the retention of ingested fluids. Sodium is particularly important for fluid restoration after exercise. The optimum means of replacing fluid and salts lost during exercise is to provide a combination of water, carbohydrate and mineral salts. Water reduces dehydration and helps to maintain blood volume, which improves performance because it lowers the heart rate and body temperature, and mineral salts help to restore electrolyte balance by boosting the process of water absorption.

In summary, it may be concluded that carbohydrate replacement during exercise may enhance performance of sports and activities, which typically deplete body carbohydrate stores, by providing an additional fuel source for the muscle. Carbohydrate and electrolyte balance keeps low heart rate as well as low blood lactate level during exercise.

References


*Reprint requests:* Dr G.L. Khanna, Senior Scientific Officer (Physiology), Human Performance Laboratory, Sports Authority of India, Jawaharlal Nehru Stadium, New Delhi 110003, India. E-mail: glichanna@rediffmail.com