Cold Drink Ingestion Improves Exercise Endurance Capacity in the Heat

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Abstract

Purpose: To investigate the effect of drink temperature on cycling capacity in the heat.
Methods: On two separate trials, eight males cycled at 66 ± 2% $V'O_{2peak}$ (mean ± SD) to exhaustion in hot (35.0 ± 0.2°C) and humid (60 ± 1%) environments. Participants ingested three 300-mL aliquots of either a cold (4°C) or a warm (37°C) drink during 30 min of seated rest before exercise and 100 mL of the same drink every 10 min during exercise. Rectal and skin temperatures, heart rate, and sweat rate were recorded. Ratings of thermal sensation and perceived exertion were assessed.
Results: Exercise time was longer ($P < 0.001$) with the cold drink (63.8 ± 4.3 min) than with the warm drink (52.0 ± 4.1 min). Rectal temperature fell by 0.5 ± 0.1°C ($P < 0.001$) at the end of the resting period after ingestion of the cold drinks. There was no effect of drink temperature on mean skin temperature at rest ($P = 0.870$), but mean skin temperature was lower from 20 min during exercise with ingestion of the cold drink than with the warm drink ($P < 0.05$). Heart rate was lower before exercise and for the first 35 min of exercise with ingestion of the cold drink than with the warm drink ($P < 0.05$). Drink temperature influenced sweat rate (1.22 ± 0.34 and 1.40 ± 0.41 $L{\bullet}h^{-1}$ for the cold and the warm drink, respectively; $P < 0.05$). Ratings of thermal sensation and perceived exertion ($P < 0.01$) during exercise were lower when the cold drink was ingested.

Conclusion*: Compared with a drink at 37°C, the ingestion of a cold drink before and during exercise in the heat reduced physiological strain (reduced heat accumulation) during* exercise, leading to an improved endurance capacity (23 ± 6%).

Introduction

The debilitating effects of heat stress on the ability to perform prolonged strenuous exercise are well established. During exercise in a hot environment, a substantial rise in body core temperature (*Tc*) is often linked with the onset of fatigue.[13,30] Fluid replacement before and during prolonged exercise in the heat has been shown to be effective in reducing the elevation of *Tc* [33] and in extending endurance capacity.[26] These studies typically involved a trial with fluid replacement and another no-fluid trial serving as control, so the benefits were likely to be attributed to the hydration effects of fluids consumed. However, Dill et al.[11] investigated the effect of drinking large volumes (2.4 L) of cold (15°C) saline on physiological responses to 2 h of walking in desert heat (37-47°C) and found that *Tc* was reduced relative to a trial where no drinks were allowed by approximately 1°C. There was no apparent difference in thermoregulatory responses, and this temperature differential is close to the value calculated from the heat deficit imposed by ingestion of the cold fluid.

Gonzalez-Alonso et al.[13] showed that lowering initial esophageal temperature by water immersion for 30 min before exercise and attenuating the rise in esophageal temperature by wearing a water-perfused jacket during exercise have separate beneficial effects in extending cycling time to exhaustion in the heat. Although pre cooling maneuvers such as exposure to cold air and water immersion can be effective in increasing tolerance to exercise in conditions of heat stress, they are impractical in the athletic, occupational, and military fields due to problems regarding time and equipment required to achieve sufficient body cooling to improve exercise performance.[25]

There is some evidence in the literature that the temperature of ingested drinks will influence body temperature, with implications for the risk of heat illness and for performance. Gisolfi and Copping[12] showed that ingestion of cold water during running resulted in a smaller rise in rectal temperature (T_{re}) during prolonged treadmill running in the heat than was observed when the same volume of water was ingested at body normal *Tc*. They also showed that ingestion of the fluid was more effective during exercise than that in the preexercise period. We have shown more recently that, when compared with the ingestion of 1.2 L of hot drinks (50°C), ingestion of the same volume of cold drinks (4°C) at rest resulted in a reduction in T_{re} of 0.7°C.[23] Ingestion of 1.2 L of cold drinks during exercise at 60% $V'O_{2peak}$ was effective in reducing the rise of T_{re} by 0.3°C at the end of exercise relative to a trial where the same volume of hot drinks was consumed.[23] No measure of performance was made in any of these studies,[11,12,23] however. The effect of drinking cold water (4°C) on endurance capacity in the heat was recently reported by Mundel et al.[29] who found that the ingestion of cold drinks, compared with drinks at 19°C (control), extended mean cycling (65% $V'O_{2peak}$) time to exhaustion in the heat (34°C) from 55 to 62 min. However, the results are difficult to interpret because an *ad libitum* drinking schedule was used, resulting in subjects consuming significantly more cold fluids (about 1.3 $L•h^{-1}$) compared with drinks at 19°C (about 1.0 $L•h^{-1}$). More recently, Lee and Shirreffs[21] have shown that ingestion of a single large (1 L) bolus of hot or cold fluid after 30 min of a 90-min exercise period influenced subsequent thermoregulatory and cardiovascular responses but did not influence performance in a brief bout of high-intensity cycling performed immediately after the 90-min steady-state exercise.

The present study aimed to investigate the effects of ingesting cold drinks on the thermoregulatory responses and endurance capacity during prolonged exercise in a hot environment. It was hypothesized that the ingestion of cold drinks, compared with the ingestion of drinks of similar volume at normal *Tc*, before and during exercise would reduce the physiological strain (T_{re}, heart rate), resulting in an extended exercise time to exhaustion in the heat.

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