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ORIGINAL RESEARCH

Comparison of Sports Drink Versus Oral Rehydration Solution During Exercise in the Heat

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Introduction—This study compared 2 commercially available beverages, an oral rehydration solution (ORS; 60.9 mM Na^+; 3.4% carbohydrate) and a sports drink (SDS; 18.4 mM Na+; 5.9% carbohydrate), on hydration and metabolism during submaximal exercise in the heat.

Methods—Ten male subjects completed two 90-min exercise trials (39ºC, 30%) of walking at 50% VO_{2max} followed by a 30-min rest period in the heat while wearing wildland firefighter personal protective clothing. After 45 min of exercise, fluid delivery by either ORS or SDS replaced 150% of sweat loss. Subjects continued the exercise for 45 additional minutes followed by a 30-min rest period. Blood samples were collected pre-exercise (0 min), post-exercise (90 min), and post-trial (120 min) to measure plasma volume (%) and blood glucose ($mg \cdot dL^{-1}$). Expired gases were collected twice for 3 min for substrate oxidation.

Results—The sweat rate and percent dehydration did not differ between the groups (P=0.86 and P=0.79, respectively). Changes in plasma volume did not differ (P=0.55). Hemoglobin levels significantly increased in both groups post-trial (P=0.009). Blood glucose was significantly greater post-trial in SDS versus ORS (116±19 vs 103±13 $mg \cdot dL^{-1}$, respectively; P=0.01). Fat oxidation was lower post-exercise in SDS vs ORS (0.38±0.1 vs 0.47±0.2 $g \cdot min^{-1}$, respectively; P=0.049).

Conclusions—These data indicate no difference in fluid retention between ORS or SDS when supplemented during exercise in the heat. This implies that fluid volume, and not drink contents, may be more important when ingested during exercise in a hot environment.

Keywords: wildland firefighter, hydration, rehydration, heat stress, fluid retention

Introduction

Prolonged exercise in the heat challenges individuals in maintaining fluid balance due to high rates of sweat loss, which can adversely affect exercise performance[1–4] and thermal strain[2,5] if fluid loss significantly exceeds fluid ingestion. To overcome environmental and metabolic heat accumulation and prevent hazardous elevations in core temperature (T_c), sweating is necessary to thermoregulate. In sports and certain occupations (eg, wildland firefighters [WLFF] and military personnel), the amount of fluid lost by sweating varies with respect to both intrinsic (genetics, body size, and heat acclimation status) and extrinsic (environmental temperature/humidity, personal protective equipment, and exercise intensity/duration) factors.[6]

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Hypohydration of approximately 3 to 4% has been shown to reduce plasma volume and thus challenge the cardiovascular system by decreasing stroke volume and cardiac output by approximately 13% while hyperthermic.[7] The effect of graded dehydration also coincides with increases in T_c, an additional factor augmenting heat stress.[5] Therefore, the American College of Sports Medicine's position on exercise and fluid replacement states that fluid intake during exercise should avoid body weight loss of >2% to prevent hypohydration but also warns against excess drinking to avoid weight gain and risk of hyponatremia.[6]

Fluid volume and composition influence the rates of absorption from the stomach to the small intestine, allowing fluids to enter the extracellular space to help maintain plasma volume.[8] Elevated sodium content of ingested fluids has been shown to significantly enhance fluid retention.[9] The presence of sodium in sports drink solutions (SDS) and oral rehydration solutions (ORS) not only enhances palatability and fluid retention but also stimulates the drive to drink.[9–11] Conversely, sodium concentrations that

are too high (>50 mmol·L^{-1}) have been shown to decrease palatability, reduce the drive to drink, and possibly result in gastrointestinal distress in occupational athletes.[12]

Historically, ORS were designed to replace fluid and electrolyte losses at rest to prevent mortality associated with acute diarrheal illnesses.[13,14] Consequently, the World Health Organization developed an ORS to aid in the recovery from acute diarrheal disease (Na^+=75 mmol·L^{-1}; Cl^-=65 mmol·L^{-1}; K^+=20 mmol·L^{-1}; citrate=10 mmol·L^{-1}; glucose=75 mmol·L^{-1}).[15] SDS are typically designed to replace fluid and electrolyte losses from sweating during exercise and contain carbohydrate (CHO) to maintain work output for extended periods.[11,16] Therefore, SDS typically contain approximately 60 g·L^{-1} CHO, 20 to 30 mmol·L^{-1} Na^+, and 2 to 5 mmol·L^{-1} K^+.[6,11] Thus, these beverages were designed for different purposes under different situations, where ORS replaces fluid and electrolytes lost due to diarrhea and vomiting and SDS replaces fluid and electrolytes lost due to sweating from exercise.

Despite the intention of their formulations, ORS and SDS are often used in situations for which they are not intended. Only recently have attempts been made to directly compare different formulations of drinks on measures of hydration. In one study, although subjects were euhydrated and at rest, ORS and, surprisingly, milk resulted in the least amount of urine output and thus the greatest fluid retained.[17] However, no studies have directly compared ORS and SDS during exercise.

The optimal composition of a fluid replacement drink has been suggested to depend on the mechanism of fluid loss (sweat, urine, respiration, or diarrhea/vomiting); therefore, drink compositions are best customized to the specific situation.[11,17] Despite these recommendations, data that compare the effectiveness of ingesting an ORS versus SDS during exercise in the heat do not exist.

Military personnel and WLFF are exposed to several factors that affect heat stress throughout the day, such as high ambient temperature, personal protective equipment, and added metabolic heat due to high-energy demands.[18,19] Previous studies of WLFF have reported water turnover as high as 7 to 9 L·day^{-1}.[18,20] With such high water turnover mostly due to sweat loss, hydration strategies involving appropriate sodium and CHO supplementation are critical to meet fluid losses and provide CHO for both safety and sustained work output.

The purpose of this study was to compare the effect of a single bolus of an ORS versus SDS beverage on hydration during exercise in the heat. The results would allow for better-informed decisions in the provision of fluids for the safety and performance of athletes, military and WLFF personnel, and others who exercise in the heat.

Table 1. Participant characteristics

Characteristic	*Mean±SD*
Age (y)	22.5±4.0
Weight (kg)	82.2±10.1
Height (cm)	182±9
Body Fat (%)	14±5
VO_{2max} (mL·kg^{-1}·min^{-1})	53.9±5.9

Methods

SUBJECTS

Ten aerobically fit adult males volunteered to participate in this study (Table 1). Before testing, each subject agreed to and signed an informed consent form approved by the University of Montana Institutional Review Board (167-16).

EXPERIMENTAL DESIGN

One week after preliminary testing, all participants (n=10) completed 2 exercise trials in a climate-controlled heat chamber (39°C; 30%) for 90 min at 50% VO_{2max} (Figure 1). Subjects were instructed to not exercise for

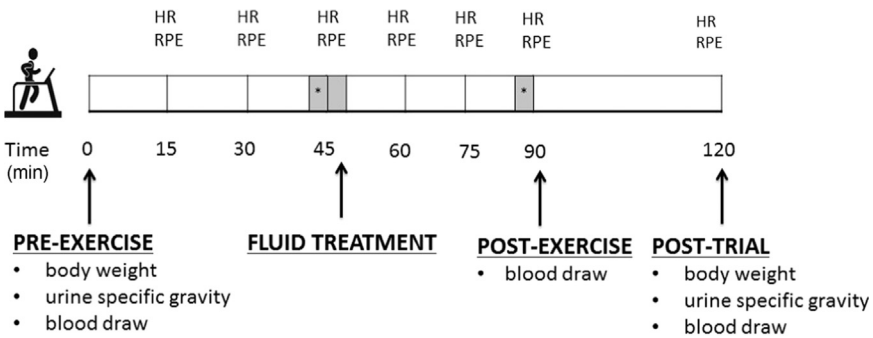

Figure 1. Schematic of study. *Metabolic gas measurement (3 min).