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Research report

# Impact of a carbohydrate–electrolyte drink on ingestive behaviour, affect and self-selected intensity during recreational exercise after 24-h fluid restriction ☆

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ABSTRACT

This study examined the effects of a carbohydrate–electrolyte drink on voluntary fluid intake, affect and self-selected intensity during recreational exercise after fluid restriction. In a randomised counterbalanced design, ten physically active adults were dehydrated via a 24-h period of fluid restriction before completing two 20-min bouts of cardiovascular exercise, 20-min of resistance exercise and 20 min on a cycle ergometer at a self-selected intensity with *ad libitum* access to water (*W*) or a carbohydrate–electrolyte solution (CES). Fluid restriction induced hypohydration of ~1.2% initial body mass. Fluid intake during exercise was greater with CES (2105 ± 363 vs. 1470 ± 429 mL; $P < 0.01$) and resulted in more adequate hydration (−0.03 ± 0.65 vs. −1.26 ± 0.80%; $P < 0.01$). Plasma glucose concentrations (4.48 ± 0.40 vs. 4.28 ± 0.32 mmol $L^{-1}$; $P < 0.01$) and pleasure ratings (2.63 ± 1.17 vs. 1.81 ± 1.37; $P < 0.01$) were greater with CES than *W*. Mean power output during exercise performed at a self-selected intensity was 5.6% greater with CES (171 ± 63 vs. 162 ± 60 W; $P < 0.05$). In physically active adults performing a ‘real-life’ recreational exercise simulation, CES resulted in more adequate hydration and an enhanced affective experience that corresponded with an increase in self-selected exercise intensity.


## Introduction

Participation in regular physical activity is recommended for promoting and maintaining general health (Haskell et al., 2007), and a large proportion of people (approximately 7 million people in the UK) choose to engage in structured aerobic and muscle-strengthening activities in a health and fitness centre context (Fitness Industry Association, 2010). However, individuals performing physical activity can experience high sweat rates and substantial water and electrolyte losses that may result in dehydration if fluids are not adequately replaced (Sawka et al., 2007). Indeed, acute mild and moderate dehydration appears common in physically active adults performing free-living exercise at fitness centres with unlimited access to water (Peacock, Stokes, & Thompson, 2011); thus potentially exposing individuals to the negative effects of dehydration on cardiovascular and thermoregulatory strain (Montain & Coyle, 1992) and subjective psychological states (Backhouse, Biddle, & Williams, 2007b).

Several studies indicate that the addition of flavouring, sodium and approximately 6% carbohydrate to water stimulates greater voluntary fluid intake and more adequate hydration during exercise in athletes (Bergeron, Waller, & Marinik, 2006; Passe, Horn, Stofan, & Murray, 2004), children (Rivera-Brown, Gutierrez, Gutierrez, Frontera, & Bar-Or, 1999; Wilk, Rivera-Brown, & Bar-Or, 2007) and older adults (Baker, Munce, & Kenney, 2005). For the recreational exerciser, there is evidence of a greater relative need to supply water over fuel during exercise (Peacock et al., 2011), while the ingestion of high-energy drinks appears counterintuitive for those concerned with achieving weight loss or energy balance. However, the provision of some carbohydrate (~2%) may improve the rate of intestinal uptake of sodium and water (Maughan & Shirreffs, 1997), while small quantities of sodium (typically 10–30 mmol/L) may enhance thirst stimulation by maintaining plasma osmolality (Noakes, Goodwin, Rayner, Branken, & Taylor, 1985) and by improving drink palatability (Wilk & BarOr, 1996).

We have extended previous findings by showing that, in comparison to water (*W*), a low-energy 2% carbohydrate–electrolyte solution (CES) enhanced fluid intake by 45% and elicited a 0.6% lower level of dehydration during simulated gymnasium-based exercise in physically active adults (Peacock, Thompson, & Stokes, 2012). However, a body water deficit can also develop following successive days of inadvertent fluid restriction (Shirreffs, Merson, Fraser, & Archer, 2004) and can amplify the negative effects of any dehydration sustained during exercise on physiological function (Montain & Coyle, 1992) and psychological states (Peacock et al., 2011). This may be particularly pertinent to the recreational exerciser given that many adults (range from 37% to 46%) arrive to take part in exercise at fitness centres with an existing fluid deficit

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(Peacock et al., 2011; Stover et al., 2006). The effects of CES in promoting voluntary rehydration during exercise after a period of fluid restriction (i.e. with high ecological validity to the type of dehydration occurring in a recreational exercise setting) remains to be established.

Nutritional supplementation studies have typically focussed on "what" the individual is feeling during exercise using ratings of perceived exertion (Borg, 1973) or on distinct mood states, and have observed few differences between carbohydrate-based and placebo conditions. This is conceptually distinct from measuring "how" people feel with reference to the affective dimension of pleasure–displeasure; which is considered a key outcome of interest when studying exercise-supplementation effects (Backhouse, Biddle, Bishop, & Williams, 2011) and a determinant of long-term adherence to structured exercise (Kwan & Bryan, 2010; Williams et al., 2008). Using the Feeling Scale (Hardy & Rejeski, 1989) as a measure of core affect, we have shown that physically active adults report "feeling better" with *ad libitum* intake of CES than *W* during gymnasium-based exercise (Peacock et al., 2012). In athletes' mouth rinsing CES, it is of note that enhanced feelings of pleasure have been shown to correspond with increased self-selected running speeds at a set perception of effort (Rollo, Williams, Gant, & Nute, 2008). This may have important implications for determining the amount of effort individuals commit to an exercise session; potentially speeding the accrual of noticeable health and fitness gains and influencing adherence to an exercise programme (Desharnais, Bouillon, & Godin, 1987). Further research is warranted to examine the effect of CES on affective states and self-selected exercise intensity in a 'real-life' recreational exercise model.

We adopted a fluid restriction protocol similar to that used previously (Oliver, Laing, Wilson, Bilzon, & Walsh, 2007; Shirreffs et al., 2004) and targeted hypohydration of approximately 1% body mass and a urine osmolality above 900 mOsmol $kg^{-1}$ after 24 h fluid restriction. The purpose of this study was to examine the effects of a low-energy carbohydrate–electrolyte drink compared to water on voluntary fluid intake and hydration status in physically active adults performing simulated gymnasium-based exercise with existing mild-to-moderate hypohydration. A further aim was to determine the effect of these nutritional supplements on cardiovascular and thermoregulatory strain, the affective dimension of pleasure–displeasure, and self-selected exercise intensity. We hypothesised that the addition of flavouring, electrolytes and carbohydrate to water would result in more effective rehydration, attenuated physiological strain, enhanced affective states and greater power output during exercise performed at a self-selected intensity.

## Methods

### *Participants*

Ten recreationally active men (age, 25 ± 4 years; body mass, 77.5 ± 8.3 kg; body fat 16.9 ± 3.7%; $VO_{2max}$ 55.1 ± 8.6 mL $kg^{-1}$ $min^{-1}$; $HR_{max}$ 198 ± 5 b $min^{-1}$) provided written informed consent before participating in the study, which was approved by the local National Health Service Research Ethics Committee. All participants were familiar with gymnasium-based exercise and were completing 1–5 structured exercise sessions per week of at least 30 min in duration.

### *Preliminary measurements*

Participants reported to the laboratory on two occasions during a 2-week period before experimental trials. Initially, participant's one-repetition maximum for chest and leg press resistance exercises was established using a resistance training machine (Concept 2 Inc., USA). The force equivalent to 75% of one-repetition maximum was calculated and used as the target force during experimental trials. Maximal oxygen uptake was then determined using a continuous incremental exercise test to volitional exhaustion on a motorised treadmill. Participants ran at a constant speed against an initial gradient of 3%, which was increased by 3% every 3 min until the point of volitional fatigue. One-minute expired air samples, ratings of perceived exertion and heart rates were measured in the final minute of each stage. On a further occasion, a tasting session was conducted to determine which of two available flavours of the carbohydrate–electrolyte drink each participant preferred. This individualised flavour was used during subsequent experimental sessions. Thereafter, participants were fully habituated with the testing procedures and performed 20-min bouts of exercise on a treadmill (Woodway, UK) and cross-trainer (Technogym, UK), respectively. The work rate equivalent to a target exercise heart rate of between 70% and 80% heart rate maximum was established and applied for all experimental trials.

### *Experimental design*

This experiment adopted a repeated-measures crossover design in which each participant completed two trials in a randomized and counterbalanced order separated by 6–10 d. Our protocol was based on previous data describing the free-living gymnasium-based exercise habits and hydration practices of recreationally active adults (Peacock et al., 2011). To maintain ecological validity to the type of day-to-day dehydration sustained by recreationally exercisers, experimental trials began with a 24-h period of fluid restriction. Participants then completed a simulated recreational exercise session with *ad libitum* access to *W* or CES throughout exercise and recovery. Over the 48 h leading up to their first trial, each individual accurately recorded their habitual diet and subsequently adhered to this diet over the 48-h period prior to their second trial (2844 ± 642 kcal $d^{-1}$, 55 ± 12% carbohydrate, 31 ± 10% fat, 14 ± 4% protein, 6.4 ± 3.3 g sodium, 9.9 ± 3.8 g chloride, 5.4 ± 1.8 g potassium). Participants were also asked to ingest fluids equivalent to 35 mL $kg^{-1}$ of body mass over the 48 h period prior to all trials (3528 ± 1006 mL $d^{-1}$ total fluid content).

### *Experimental protocol*

Participants arrived in the laboratory between 08.00 and 09.00 h to begin the 24-h period of fluid restriction. After providing a urine sample and emptying their bladder, participants' nude body mass was recorded, before a baseline blood sample was collected. Participants were provided with breakfast, lunch and dinner food parcels which were to be consumed between 09.00–09.30, 12.30–14.00 and 17.30–19.30 h, respectively. Food parcel contents were based on dietary choices pre-selected by participants from a list of food options low in water content. Participants accurately adhered to this diet in the 24 h period prior to both trials (2931 ± 578 kcal $d^{-1}$, 54 ± 10% carbohydrate, 30 ± 8% fat, 16 ± 3% protein, 5.6 ± 1.4 g sodium, 8.9 ± 2.2 g chloride, 5.6 ± 1.2 g potassium, 1174 ± 192 mL total fluid content).

Participants returned to the laboratory at the same time of day the following morning, and having swallowed an ingestible temperature sensor capsule 8 h prior to arrival. Following a 15 min period of seated rest, a pre-exercise blood sample and 5-min expired gas sample were obtained. Participants then emptied their bladder and provided a urine sample prior to a recording of nude body mass. Participants were then instrumented with a chest strap and heart rate monitor before changing into shorts, t-shirt and training shoes. Immediately prior to exercise, subjective ratings of pleasure–displeasure were assessed. The exercise protocol