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Fluid, energy and nutrient recovery via ad libitum intake of different fluids and food

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HIGHLIGHTS

- When food is co-ingested, fluid restoration is not influenced by the choice of water, sports drink or a milk-based beverage.
- Whereas, prescribed beverage studies have indicated a beverage's composition has a substantial influence on fluid recovery.
- Active individuals self-select foods, altering nutrient intake and ultimately fluid retention.
- Acute energy intake is substantially increased with the selection of calorie containing beverages

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ABSTRACT

Introduction: This study compared the effects of ad libitum consumption of different beverages and foods on fluid retention and nutrient intake following exercise.
Methods: Ten endurance trained males (mean ± SD; Age = 25.3 ± 4.9 years, VO_2max = 63.0 ± 7.2 $mL \cdot kg \cdot min^{-1}$) performed four trials employing a counterbalanced, crossover design. Following 60 min of exercise (matched for energy expenditure and fluid loss) participants consumed either water (W1 and W2), a sports drink (Powerade® (P)) or a milk-based liquid meal supplement (Sustagen Sport® (SS)) over a four hour recovery period. Additionally, participants had access to snack foods on two occasions within the first 2 h of recovery on all trials. All beverages and food were consumed ad libitum. Total nutrient intake, urine volume, USG, body weight as well as subjective measures of gastrointestinal tolerance and thirst were obtained hourly. Plasma osmolality was measured pre, post, 1 and 4 h after exercise.
Results: Total fluid volume ingested from food and beverages in W1 (2.28 ± 0.42 L) and P (2.82 ± 0.80 L) trials were significantly greater than SS (1.94 ± 0.54 L). Total urine output was not different between trials (W1 = 644 ± 202 mL, W2 = 602 ± 352 mL, P = 879 ± 751 mL, SS = 466 ± 129 mL). No significant differences in net body weight change was observed between trials (W1 = 0.01 ± 0.28 kg, W2 = 0.08 ± 0.30 kg, P = −0.02 ± 0.24 kg, SS = −0.05 ± 0.24 kg). Total energy intake was higher on P (10,179 ± 1484 kJ) and SS (10,577 ± 2210 kJ) compared to both water trials (W1 = 7826 ± 888 kJ, W2 = 7578 ± 1112 kJ).
Conclusion: With the co-ingestion of food, fluid restoration following exercise is tightly regulated and not influenced by the choice of either water, a carbohydrate-electrolyte (sports drink) or a milk-based beverage.

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[1] Please note that we are seeking support for the manuscript to indicate this was a co-first author paper. The research aim was divided in two parts – 1. hydration assessment and 2. nutrient intake from different beverage treatments. The two student researchers, (NC and EI), were assigned lead responsibility for one aspect of the study, with the results combined for this manuscript.

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1. Introduction

Nutrition recovery is vital to facilitate improved exercise capacity and performance, whilst also promoting optimal training adaptation [6]. Appropriate fluid and nutrient intake following aerobic exercise can alter molecular responses to training, modify muscle-damage repair processes, cause changes to the restoration of glycogen as well as restore water and electrolyte balance [13]. Evidence-based guidelines highlight the considerations required to address post-exercise nutritional issues [1,2]. These recommendations often focus on individual aspects of recovery such as fluid balance restoration [1], muscle protein resynthesis [2] or substrate replenishment [2]. However, in practical terms, these issues require concurrent consideration.

Athletes often finish exercise in fluid deficit [1], which has resulted in considerable interest in understanding factors influencing fluid recovery [20,32,34]. Studies investigating fluid retention following exercise typically employ prescribed drinking protocols to explore the impact of a single ingredient (e.g. carbohydrate, sodium) or volume manipulations on fluid balance [14–16,20,21,23–25,29,33,35]. In contrast, recent evidence suggests that consuming beverages containing a variety of nutrients, such as milk and milk-based supplements, may promote greater fluid retention [10,31,36]. The consumption of beverages with diverse nutrient profiles are likely to influence many aspects of recovery in addition to fluid retention.

To date, very few studies investigating fluid retention have employed protocols consistent with an applied environment where athletes drink voluntarily (ad libitum) and are also encouraged to consume food. Studies using prescribed drink volumes do not consider factors such as thirst, palatability, and gastrointestinal comfort; which are likely to influence the volume of beverage consumed in practice [11]. Investigations employing ad libitum consumption of beverages accompanying exercise indicate that an individual's consumption of different beverages can be highly variable [22] even with similar levels of exercise induced fluid loss [4]. Furthermore, in the hours following exercise athletes often consume food, in addition to fluid, which is likely to influence both fluid consumption and retention. Only two studies have investigated the impact of food on fluid balance [19,26]. Collectively, these studies indicate that consuming food may enhance fluid retention. However, only limited foods items have been examined (rice/beef meal [19], beef jerky [26]) and on both occasions fluid intakes were prescribed. To date, no study has investigated the impact of ad libitum food and beverage consumption on fluid retention and nutrient intake during post-exercise recovery.

Therefore, the aim of this study was to compare the effects of ad libitum consumption of different beverages in combination with snack foods on the recovery of exercise-induced fluid loss and energy expenditure. It was hypothesised that when consumed with food, beverages with different nutrient profiles would facilitate different volumes of consumption, yet result in similar fluid retention.

2. Methods

2.1. Participants

Ten endurance trained (cyclists and/or triathletes) men (mean ± SD; age = 25.3 ± 4.9 years; height = 177.5 ± 6.1 cm; body weight = 70.3 ± 5.8 kg; VO_{2max} = 63.0 ± 7.2 $mL \cdot kg \cdot min^{-1}$) who trained and/or competed ≥10 $h \cdot week^{-1}$ were recruited to participate. Participant numbers were established using power calculation software (G*Power Version 3.1.9.2, University Kiel Germany, 2014) and experience with likely attrition. With an effect size of 0.5, power ($1 - \beta$) of 0.80 and $\alpha = 0.01$, projections suggest 10 participants were required to detect a 0.5 kg difference in net fluid balance. This value was established as the least significant difference between group means based on previous rehydration investigations which have also incorporated cross-over study designs [4,10]. The investigation was approved by the Griffith University Human Research Ethics Committee (protocol: 2014/868//HREC) (removed for blind review), and all participants provided written, informed consent before enrolment.

2.2. Study design

A timeline of the experimental trial is displayed in Fig. 1. Each participant attended the laboratory on five separate occasions; one preliminary and four repeated measures experimental trials separated by at least 5 days using a counterbalanced (incomplete Latin square) design. Each trial involved exercise-induced fluid loss prior to the ad libitum provision of one of three different trial beverages (W1 – Water, W2 – Water 2, P – Powerade®, SS – Sustagen Sport®) and food. To blind participants from the true nature of the investigation, participants were informed the purpose was to examine the influence of different beverages on post-exercise cognitive function (sham questions and a short cognitive function task were administered throughout the trials). Participants were given access to food for 15 min at the end of the first and second hour of the recovery period prior to undertaking the cognitive function test. Participants were not advised that food intake was being monitored until the completion of the study.

2.3. Screening and preliminary testing

Participants were required to be aged between 18 and 40 years; without history of cardiovascular, metabolic or kidney diseases; not taking any medications known to influence lipid or carbohydrate (CHO) metabolism; not known to have food allergies or intolerances. All participants completed preliminary health screening prior to undertaking a graded exercise test on an electronically braked cycle ergometer (Lode Excalibur Sport; Lode BV, Groningen, Netherlands). The protocol began at 100 W, and increased in 50 W increments every 2.5 min until volitional exhaustion with participant's respiratory gases sampled continuously by breathing into a calibrated gas analysis system (Medgraphic Ultima, MGC Diagnostics and Medisoft, USA). Method for determining maximum O_2 consumption (VO_{2max}) and Peak Sustainable Power Output (PPO) have previously been described [9] with these values being used to establish initial exercise intensities for subsequent trials.

2.4. Pre-trial standardisation

Participants were instructed to abstain from alcohol for 24 h and to avoid caffeine-containing products and moderate-strenuous exercise for 12 h prior to experimental trials. For 24 h prior to the first trial, participants completed a diary recording all food and drink consumed which also included a pre-packaged evening meal for each trial. The meal (Lasagne (Lean Cuisine®), frozen garlic bread (Coles® Smartbrand) and 600 mL Gatorade (Pepsico®)) was designed to provide ~60 $kJ \cdot kg^{-1}$ body weight (BW) of energy. Participants were required to abstain from food for at least 10 h prior to arrival at the laboratory for the experimental trial. Participants were also instructed to drink 1000 mL of plain water prior to retiring to bed to assist with hydration. Participants were required to repeat this dietary intake prior to all subsequent trials.

2.5. Resting, pre-exercise period

Participants arrived to the laboratory ~0700 h with compliance to pre-experimental conditions being verbally acknowledged. An initial urine sample was collected to determine urine specific gravity (USG; Palette Digital Refractometer, ATAGO, USA). The participants were able to start exercising after a USG reading < 1.020 was obtained. Participants who recorded a USG reading ≥ 1.020 were provided with a bolus of plain water (500–1000 mL) to consume within ~5 min, followed by a 30 min rest period before a subsequent USG measure was taken. If USG