The effects of carbohydrate supplementation on multi-day wilderness expedition performance

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Introduction

During expeditions and military field training energy expenditure often exceeds intake (Tharion *et al*., 2006). Inadequate diets compromise physical exercise capacity and health. Consequently, it is pertinent to devise practical nutritional strategies to increase energy and fluid provision in these scenarios.

High carbohydrate diets have been shown to improve or preserve exercise capacity during periods of intense training compared with normal mixed diets (Kirwan *et al*., 1988; Simonsen *et al*., 1991; Achten *et al*., 2004). These diets were also associated with greater percentage of completed training and preserved body weight.

Compared with water alone the addition of carbohydrate to beverages has been shown to increase voluntary fluid intake and aid fluid retention during and following exercise (Maughan *et al*., 1997).

Where food availability and preparation is compromised, carbohydrate drinks may prove a palatable and practical method to maximise performance. Therefore, the purpose of this study was to investigate the effect of carbohydrate supplementation on physical performance, body composition and hydration status during a five-day wilderness expedition.

Methods

With institutional ethical approval, 20 students (16 males, 4 females; age mean = 20.7, *s* = 1.6 years; body mass mean = 73.1 , *s* = 11.3 kg) completed a five day, self supported, expedition. Environmental conditions varied from -4 to 20 °C. Throughout, participants consumed *ad- libitum* a flavoured 10% solution carbohydrate energy drink (CHO: PSP) or an indistinguishable placebo (PLB) in a randomised, double blind manner.

Performance was measured fasted on days 1, 3, 5 (0800 h) by the time to complete a 400 m rucksack walk-stepping task where males and females carried 15 and 13.5 kg, respectively. Participants completed eight circuits of 50 m; where each circuit began with 20 steps on to a 22 cm platform.

Energy balance was calculated as energy intake minus energy expenditure on Day 3. Energy expenditure was estimated from MET tables (Ainsworth *et al*., 2000) whilst intake and dietary composition was estimated from self-report weighed diet records (*Dietmaster, Version 4, Swift computer systems*).

Body composition was measured fasted by a three compartment model (Lohman, 1986) pre (Day 0, 1800 h) and post expedition (Day 5, 1800 h). Fat mass, bone mineral content and residual were determined by underwater weighing and dual energy x ray absorptiometry (QDR 1500, Hologic). Residual lung volume was predicted from demographic and anthropometric data (Boren *et al*., 1966).

Urine samples were collected on Day 0 (1800 h), Day 1 (0700 h), Day 3 (0700 & 1800h) and Day 5 (0700 h & 1800 h) and osmolality was determined using a freezing point depression osmometer (*Model 3MO, Advanced Instruments*) with an intra-assay coefficient variation of 2.0%. Total and supplement fluid intake was recorded by self report diary at the end of each day.

Data were analysed by mixed model analysis of variance (allocation x time) or by independent *t* tests (CHO vs. PLB). Appropriate adjustments to the degrees of freedom were made in cases where the assumptions of sphericity and normality were violated. *Post Hoc* Tukey's HSD and Bonferroni adjusted *t*-tests were used where appropriate. Significance was accepted at $P<0.05$. Data are presented as means ± *s*.

Results

Time to complete the performance task was not affected by allocation ($p = 0.269$) but tended to change over time (Day 1 vs. 3 vs. 5: mean 376 ± 43 vs. 383 ± 41 vs. 367 ± 52 seconds, $p = 0.088$, $\eta^2 = 0.2$).

There was no interaction for any of the body composition parameters ($p > 0.48$). However, body mass and fat mass decreased whilst fat-free mass increased post *vs.* pre-expedition in CHO and PLB groups ($p = 0.007 - 0.001$, $\eta^2 = 0.3 - 0.6$, Figure 1).

Both CHO and PLB groups were in negative energy balance, albeit trends of reduced energy deficit in the CHO group were observed (CHO vs. PLB: mean -1882 ± 1223 vs. -2981± 1586 kcals·day^{-1}, $p = 0.094$, $\eta^2 = 0.1$). Total dietary carbohydrate intake was significantly higher in participants receiving CHO (CHO vs. PLB: mean 7.1 ± 1.6 vs. 4.2 ±1.8 g·kg^{-1} BM·day^{-1}, $p = 0.001$, $\eta^2 = 0.5$).

	Allocation	Pre Expedition – Day 0	Post Expedition – Day 5
Body mass (kg)	CHO	72.4 ± 12.4	71.8 ± 11.7 *
	PLB	71.9 ± 10.5	71.0 ± 10.0 *
Fat mass (kg)	CHO	21.8 ± 8.2	18.9 ± 7.1 *
	PLB	19.7 ± 6.8	16.6 ± 6.9 *
Fat-free mass (kg)	CHO	50.6 ± 9.0	52.9 ± 9.8 *
	PLB	52.2 ± 11.5	54.4 ± 11.1 *

Figure 1. Body composition in carbohydrate (CHO) and placebo (PLB) beverage groups pre and post a five day wilderness expedition. Values are means ± *s,* n = 9 CHO; 9 PLB. * $p < 0.01$ *vs.* Day 0.

There was a significant interaction for *ad-libitum* fluid intake ($F_{(4,68)} = 2.874$, $p = 0.029$: Figure 2) but there were no differences between CHO and PLB at any time. The CHO group did have a greater fluid intake on Day 4 compared with Day 1 ($p = 0.0495$, $\eta^2 = 0.1$). In contrast, fluid intake was unchanged in the PLB group. The supplemented beverage was 90 and 72% of total daily fluid intake in CHO and PLB groups, respectively.

There was a a significant interaction for urine osmolality ($F_{(5,85)} = 3.224$, $p = 0.01$: Figure 3) but there were no differences between CHO and PLB at any time. Urine osmolality was significantly lower in the CHO group post expedition (Day 5 vs. Day 0 and 1, $p=0.010$, $\eta^2=0.2$) whereas it remained unchanged in the PLB group

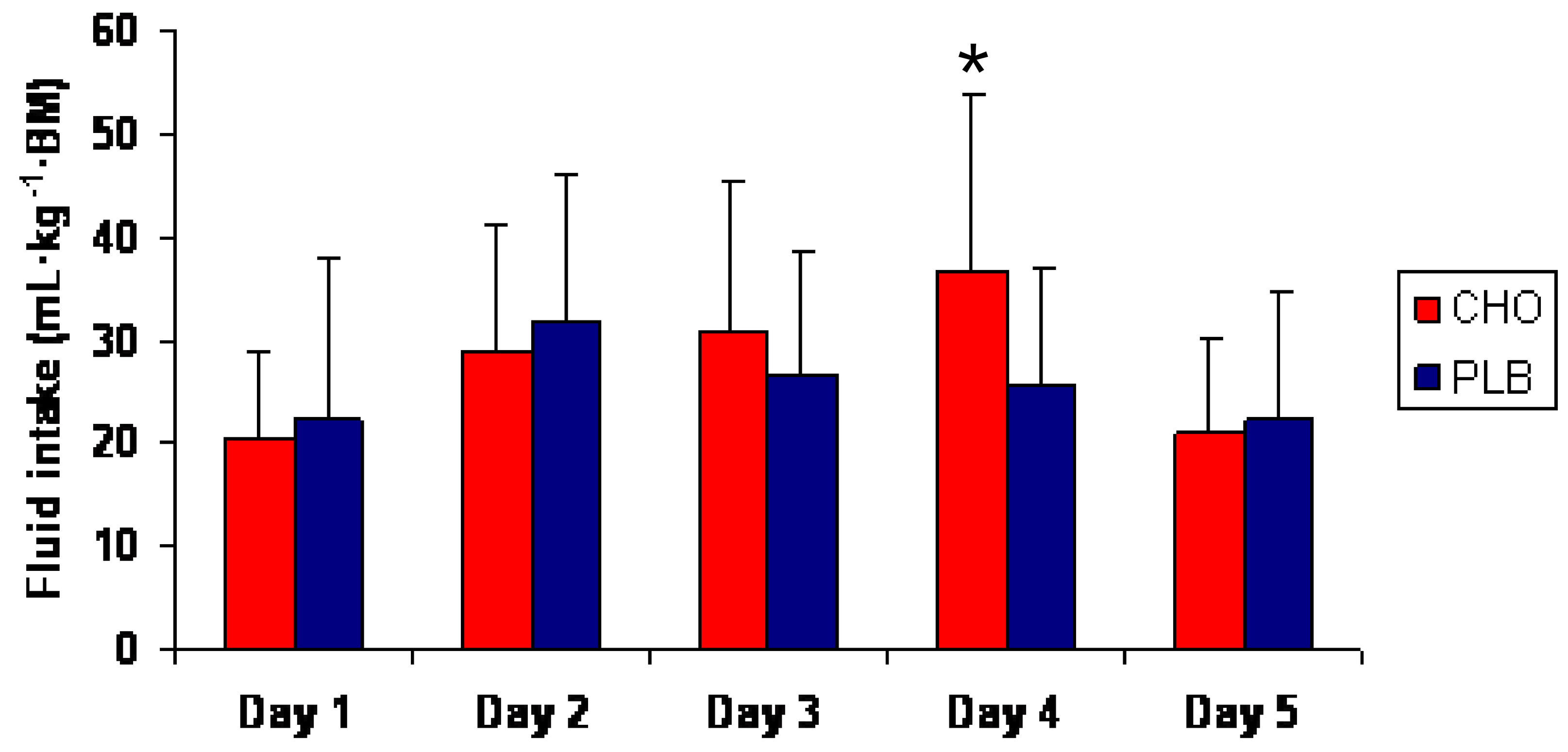

Figure 2. Daily ad-libitum fluid intake in carbohydrate (■) and placebo (■) beverage groups during a five day wilderness expedition. Values are means ± *s,* n = 9 CHO; 10 PLB. * $p < 0.05$ *vs.* Day 1.

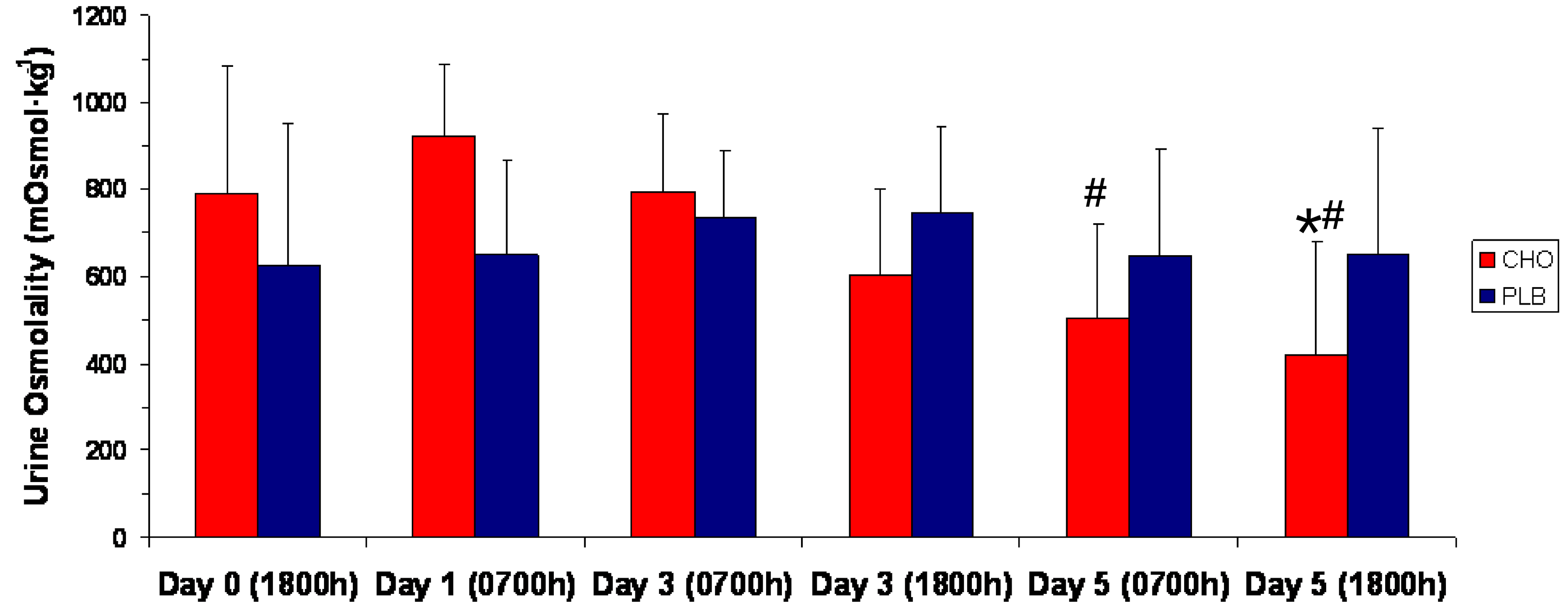

Figure 3. Urine osmolality in carbohydrate (■) and placebo (■) beverage groups during a five day wilderness expedition. Values are means ± *s,* n = 9 CHO; 10 PLB). * $p < 0.05$ *vs.* Day 0 (1800 h). # $p < 0.05$ *vs.* Day 1 (0700h)

Discussion

During the five-day wilderness expedition, participants were in a negative energy balance; however, physical performance was unaffected, possibly because of beneficially altered body composition or adequate carbohydrate intake. Furthermore, carbohydrate supplementation did not alter energy intake, body composition or performance.

The carbohydrate supplementation successfully increased carbohydrate intake and improved hydration status most probably via an increase in total fluid intake. Future research should examine the use of chronic carbohydrate supplementation in scenarios where energy and carbohydrate intake are restricted.

In conclusion, carbohydrate beverages are a practical method to increase carbohydrate intake and promote hydration status in expedition settings where food availability and preparation are compromised.

References and Acknowledgements

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