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## Calorie-Containing Recovery Drinks Increase Recreational Runners' Voluntary Energy and Carbohydrate Intake, with Minimal Impact on Fluid Recovery

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## 1 Introduction

2 Post-exercise “recovery stations” (where food and fluid are available) are a common feature of  
3 developed sports programs for athletes and routinely organised for mass participation events  
4 (e.g. fun runs, marathons, triathlons). While these are often critical to promote recovery for  
5 individuals training or competing multiple times a day, this is less so for recreational athletes,  
6 as both fluid and substrate losses can be restored within 24hrs (Burke, van Loon, & Hawley,  
7 2017; B. Desbrow, Barnes, Young, Cox, & Irwin, 2017). Indeed, the consumption of caloric  
8 beverages in the immediate post-exercise period could result in undesirable outcomes. For  
9 instance, we have recently demonstrated that *ad libitum* access to calorie containing beverages  
10 (i.e. carbohydrate (CHO)-electrolyte (sports) beverages and milk-based drinks) in the  
11 laboratory, increases acute energy intake (in both males and females)(Campagnolo et al., 2017;  
12 McCartney, Irwin, Cox, & Desbrow, 2018). Hence, the immediate provision of food and  
13 calorie-containing beverages to recreational athletes could assist in meeting post-exercise  
14 recovery nutrition goals or alternatively, compromise broader health or body composition  
15 goals; particularly if subsequent dietary intake is not adjusted to compensate for the additional  
16 post-exercise intake.

17 To date, only one study has examined if the provision of foods/fluids at a recovery station  
18 immediately following a mass-participation event influences post-exercise dietary intake. In  
19 this study, providing *ad libitum* access to water, a commercial sports drink and sliced fruit in a  
20 recovery area had a positive influence on dietary intake (increasing fruit consumption)  
21 compared to when no recovery area was available (B. Desbrow et al., 2017). However, access  
22 to a recovery station did not influence total fluid or macronutrient intake across the remainder  
23 of the day or next morning hydration status (Urine Specific Gravity (U<sub>SG</sub>)). Hence, it was  
24 concluded that recovery stations served to promote positive lifestyle behaviors in recreational  
25 athletes.

26 Food/fluid items within recovery stations are not standardized, and providing/restricting access  
27 to certain foods/fluids is likely to influence recovery and subsequent intake. In the former  
28 investigation, a range of items were provided including multiple beverages (calorie and calorie-  
29 free options) as well as sliced fruit (B. Desbrow et al., 2017), which are likely to have affected  
30 the recovery area's potential to influence subsequent dietary intake. In contrast, many events  
31 have limited resources (i.e. funds, personnel, capacity to handle perishable items), which dictate  
32 that access to fluid is typically prioritized. Hence, understanding how (if at all) access to  
33 different beverages (alone) immediately following recreational exercise influences dietary  
34 intake will assist in the development of recommendations for recovery provisions following  
35 mass participation events where limited resources exist.

36 In laboratory settings, the exclusive provision of commercial sports drinks (vs water), appears  
37 to result in an increase to *ad libitum* fluid intakes, both during (Passe, Horn, Stofan, & Murray,  
38 2004) and following exercise (Campagnolo et al., 2017; Wilmore, Morton, Gilbey, & Wood,  
39 1998). However, athletes may seek alternative fluid options following exercise, including  
40 beverages that contain alcohol (particularly at the recreational level) (O'Brien & Lyons, 2000).  
41 Low-alcohol beer (LA-Beer) (i.e. <1% ABV) is widely available, has been marketed as a  
42 recovery beverage (see <https://int.erdinger.de/markenwelt/alkoholfrei/tea.html>), and may make  
43 a valuable low-calorie contribution to fluid replacement following exercise (Maughan et al.,  
44 2016). Furthermore, in contrast to mid- and full-strength beer, LA-beer is unlikely to deliver a  
45 large absolute volume of alcohol and thus impair aspects of post-exercise recovery (e.g.  
46 rehydration (B Desbrow, Murray, & Leveritt, 2013), or muscle protein resynthesis (Parr et al.,  
47 2014)). How access to different commercial beverages during the immediate post-exercise  
48 window influences acute voluntary fluid ingestion and subsequent nutrient intake by  
49 recreational athletes in a field setting remains unknown.

50 Therefore, the aim of this investigation was to assess if providing different (but common)  
51 beverages in a post-exercise recovery area influences voluntary fluid consumption, subsequent  
52 dietary intake and next-morning hydration status. We hypothesised that (1): commercial sports  
53 drinks would be consumed in greater quantities than either water or a LA-Beer, however, this  
54 difference would not be sufficient to influence next-morning hydration status; and (2):  
55 immediate access to a calorie-containing beverage (LA-Beer or sports drink) would result in  
56 greater acute energy intakes post-exercise (compared to water) that would not be compensated  
57 for by a reduction in food/fluid intake over the remainder of the day.

## 58 **Method**

### 59 Participants and Experimental Design

60 The participant cohort consisted of consenting students who agreed to undertake a fluid and  
61 diet monitoring activity incorporated into an undergraduate sports nutrition course. Participants  
62 (n=132) completed two 10km afternoon runs (repeated measures counterbalanced design)  
63 separated by one week. Immediately after the first run, participants were randomly assigned to  
64 separate recovery areas providing access to one beverage (based on personal preference).  
65 “Non-Beer Drinkers” (n=78 (38 male), mean±SD, age=21.8±2.2y, body mass (BM)=71±13kg)  
66 received either Water or sports drink (SD) (Gatorade® (PepsiCo), lemon-lime flavour). “Beer  
67 Drinkers” (n=54 (41 male), age=23.9±5.8y, BM=76±13kg) received LA-Beer (Hahn Ultra®,  
68 (LionCo), 0.9% ABV) or SD (Gatorade® (PepsiCo), orange flavour). Participants remained in  
69 the recovery area for 30-60 min and were given access to the alternate recovery beverage the  
70 following week. All fluid within the recovery area was consumed *ad libitum* and measured by  
71 trained observers (i.e. post-exercise fluid intake). Participants recorded all food and fluid  
72 consumed for the remainder of both trial days via food diary and photographs, which were  
73 subsequently analysed (energy, CHO and water) by a dietitian. Participants collected a next  
74 day waking urine sample to assess hydration status. The events commenced at the same time  
75 (1400hrs), under similar environmental conditions (Trial 1 = 22.2°C, 63% RH and Trial 2 =  
76 25.8°C, 24% RH) and were conducted on an athletics track (400m). Prior to data collection, all  
77 procedures were approved by the XXXX (removed for review) University Human Research  
78 Ethics Committee (HREC2017/351).

### 79 Pre-trial Procedures

80 On the morning of trials (consecutive Mondays), participants were encouraged to consume the  
81 same food. Once at the athletics track, participants self-categorized their pre-exercise dietary

82 intake as “Nothing”, “Fluids only”, “Snack±Fluids”, “Breakfast only”,  
83 “Breakfast+Snack±Fluids”, “Breakfast+Lunch” or “Breakfast+Lunch+Snack±Fluids”. Pre-  
84 exercise intake was considered “matched” when it was reported within one ordinal category  
85 (e.g. *Breakfast+Snack±Fluids* = *Breakfast+Lunch*). Participants then provided a urine sample  
86 for the determination of  $U_{SG}$  (calibrated Pen Refractometers, ATAGO, USA) and urine color  
87 (8 point scale) (Armstrong et al., 1994). Immediately prior to commencing the run, participants  
88 self-reported their thirst and hunger (10 point scales), and recorded a nude BM.

## 89 Experimental Procedures

90 Participants were encouraged to complete the 10km run at a sustainable pace able to be  
91 replicated in both trials. A combination of running and walking was permitted, however,  
92 participants were encouraged to run initially to induce fluid loss via sweating. To facilitate the  
93 calculation of fluid loss, participants were not allowed to drink throughout the task. Total  
94 distance and time were monitored by either GPS device (when available) or via lap counting  
95 and manual time keeping by one of the investigators.

96 On completion of the 10km trial, participants repeated the thirst, hunger and nude BM measures  
97 before being allocated into a relevant treatment arm. The calorie-containing treatments  
98 supplied 103 vs 57 kJ·100mL<sup>-1</sup> (SD vs LA-Beer) of energy, 6 vs 1.8 g·100mL<sup>-1</sup> of CHO and  
99 51 vs 3 mg·100mL<sup>-1</sup> of sodium, respectively. The decision to use LA-Beer (rather than beer  
100 with higher %ABV) was partly due to ethical/safety concerns associated with managing the  
101 large participant cohort. All beverages were initially served cool (~10°C). Participants were  
102 required to stay in the recovery area for 30-60min and obtain fluid from bulk supplies (beer  
103 available on tap) using a standardized (355mL) disposable cup. Participants were told to “*drink*  
104 *as much as they wanted*” and were able to refill (only empty) cups. Beverage liking and  
105 refreshingness were evaluated at the onset of drinking (on a scale of 1 to 10). All beverage

106 volumes were recorded by weight (via digital scales), with participants instructed to return any  
107 unconsumed portion of their final drink for the determination of total beverage intake. Trained  
108 observers (student non-participants and investigators) monitored all drink volumes and  
109 compliance with drinking instructions. On leaving the recovery area, participants were  
110 provided with a urine specimen container for collection of a first morning sample the following  
111 day, used to determine  $U_{SG}$  and Urine color.

## 112 Dietary Analysis

113 For both trial days, participants were instructed to record all food and fluid consumed via a  
114 food diary (including photographs), commencing from their departure of the recovery area until  
115 midnight. Participants were encouraged to include a self-selected fiducial marker (e.g. de-  
116 identified credit card) in each image to assist the investigator in the estimation of portion size.  
117 Completed food diaries/photos were analyzed for total energy (kJ), CHO (g), and water (L) by  
118 an experienced Accredited Practising Dietitian using Foodworks 9<sup>®</sup> (Xyris Software, Brisbane)  
119 dietary analysis software.

## 120 Statistical Analysis

121 Planned comparisons employing paired-samples t-tests were used to assess differences in  
122 hydration and dietary outcome variables (Water vs SD and SD vs LA-Beer). Correlations  
123 between beverage “liking” and ad libitum consumption have been performed. Statistical  
124 significance was considered when  $p < .05$ . All data are Mean $\pm$ SD, where statistical differences  
125 existed, effect size (ES) was calculated as Cohen’s  $d$ .

## 126 Results

127 Pre Trial: Despite advice to standardize pre-exercise food intake, 9 (7%) participants (7 Water  
128 vs SD, 2 LA-Beer vs SD) had “unmatched” categories of food/fluid prior to trials. Therefore,

129 all analysis was performed on both the entire dataset, and only those with “matched” pre-  
130 exercise food intake categories.

131 Whether the analysis was performed on all (Table 1) or only those with matched pre-exercise  
132 food intake categories did not influence any outcome variables (including those collected post-  
133 exercise and the next-day). Furthermore, trial order analysis revealed no effect of trial sequence  
134 on body mass loss, run time, post-exercise subjective thirst/hunger ratings or drink volume  
135 consumed ( $p$ 's > .05).

136 INSERT Table 1 about here

137 Water vs SD: Within the recovery area, both beverages were equally well received (liking  
138  $p$ =.420 and refreshment  $p$ =.089), and voluntarily consumed in similar quantities ( $p$ =.157)  
139 (Table 1 and Figure 1). When provided access to SD, participants recorded a greater daily  
140 (recovery + rest of day) energy (av.  $\Delta$  ~800 kJ,  $p$ =.002, ES = .38), CHO (av.  $\Delta$  ~35 g,  $p$ <.001,  
141 ES = .49) and fluid (av.  $\Delta$  ~200 mL,  $p$ =.026, ES = .26) intake.

142 INSERT Figure 1 about here

143 SD vs LA-Beer: SD was subjectively more enjoyable ( $p$ <.001) and refreshing ( $p$ <.001) than  
144 the LA-Beer, and voluntarily consumed in larger quantities (av.  $\Delta$  ~200 mL,  $p$ =.004, ES = .41)  
145 (Table 1 and Figure 1). Participants recorded similar daily energy ( $p$ =.591) and CHO ( $p$ =.833)  
146 intakes with both beverages. A small, but significant, reduction in total water intake (av.  $\Delta$   
147 ~250 mL,  $p$ =.006) remained at the end of the day following the LA-Beer trial.

148 Post Trial: Next morning  $U_{SG}$  values were not different between Water vs SD (Water =  
149  $1.020 \pm 0.009$ , SD =  $1.025 \pm 0.037$ ,  $p$ =.257). However, a difference was detected between SD vs  
150 LA-Beer (SD =  $1.021 \pm 0.009$ , LA-Beer =  $1.016 \pm 0.008$ ,  $p$ =.002, ES = .42). No differences were  
151 observed between any treatments for urine color.



152 **Discussion**

153 This study examined the impact of providing different beverages to recreational athletes  
154 following a self-paced 10km run on acute *ad libitum* fluid consumption, subsequent dietary  
155 intake and next-morning hydration status. Results indicated that immediately following  
156 exercise, individuals voluntarily replaced ~50-65% of the fluid lost via sweat, with the volume  
157 consumed associated with the palatability of the beverage. Water and commercial sports drink  
158 appeared equally well received, whereas, the low-alcohol beer was consumed in smaller  
159 volumes. When beverages differed in caloric density (i.e. SD vs Water), individuals did not  
160 compensate for the additional energy in the beverage by reducing subsequent post-exercise  
161 food/fluid intake. Beverage availability did not meaningfully influence next morning measures  
162 of hydration status.

163 In contrast to our hypothesis, the provision of a commercial SD did not result in significantly  
164 greater *ad libitum* fluid intakes compared to the Water trial during the immediate post-exercise  
165 period. Access to either of these beverages immediately following exercise resulted in similar  
166 intakes (i.e.  $\Delta$  ~50 mL). When provided throughout and after exercise, previous observations  
167 indicate that athletes voluntarily drink larger volumes (i.e.  $\Delta$  100-350 mL) of sweetened  
168 beverages compared to water (Passe, Horn, & Murray, 2000; Passe et al., 2004; Wilmore et al.,  
169 1998). While statistically significant, these differences are likely to have a trivial impact on the  
170 fluid recovery of recreational athletes undertaking exercise in contexts similar to the current  
171 study (i.e. ~2% body weight shift with considerable time between exercise bouts). Collectively,  
172 results suggest that consumption of SD or similarly sweetened beverages for rehydration  
173 purposes in this recreational setting is unwarranted.

174 The current study is the first to report on *ad libitum* intakes of LA-beer compared to SD  
175 following exercise. Results indicate that participants consumed ~200 mL (on average) less LA-

176 beer compared to SD in the immediate post-exercise period. The same relationship was evident  
177 when the analysis was conducted exclusively on the male participants (results not provided).  
178 Despite participant's being informed of the "low" alcohol content of the beer, it is not possible  
179 to determine if concerns with the alcohol per se influenced consumption (i.e. either by avoiding  
180 less "socially desirable" LA-beer or trepidations regarding alcohol intake from sceptical  
181 participants). That said, the reduced volume can, in part, be explained by lower palatability  
182 (average rating ~1.5 lower out of 10) reported during the LA-Beer trials (see supplementary  
183 figure). Furthermore, carbonation has previously been associated with reduced voluntary fluid  
184 consumption following exercise (Passe, Horn, & Murray, 1997). Interestingly, the fluid deficit  
185 observed on LA-Beer trials further increased to ~350 mL by the end of the day. This suggests  
186 that maximising fluid intakes during the immediate post-exercise period (i.e. providing access  
187 to palatable fluids) assists in optimising fluid intakes over the remainder of the day.

188 While the results of our previous investigation indicated that a recovery intervention did not  
189 influence total energy or macronutrient intake, this result was in the context of numerous  
190 fluid/food items (varying in calorie density) being available. The current design considered the  
191 impact of providing one beverage within a recovery area (as might be the case under funding  
192 constraints). In support of our hypothesis, the exclusive provision of a calorie-containing  
193 beverage (either SD or LA-Beer) appeared to influence energy intake values recorded at the  
194 end of trial days. In fact, the energy/CHO surplus created by the provision of SD vs Water  
195 (mean ~850 kJ/ ~45 g) was almost completely preserved until the end of our recording period.  
196 This finding is consistent with recent laboratory work (using trained participants) indicating  
197 that the acute energy provision provided by caloric beverages is not typically offset by a  
198 subsequent reduction in food/fluid intake over the remainder of a day (Campagnolo et al., 2017;  
199 McCartney et al., 2018).

200 Collectively, our two investigations into recovery areas following mass participation  
201 recreational events suggest that (1): the immediate provision of water is sufficient to initiate  
202 recovery, (2): recovery stations offering healthy options (e.g. fruit) may reinforce and align the  
203 benefits of healthy eating with regular physical activity (i.e. a “teachable moment” for health  
204 advocacy (Lawson & Flocke, 2009)), and (3): if the intention is to increase energy intake post-  
205 exercise (e.g. multi-day (competitive or charity-type) events), the provision of calorie-  
206 containing fluids (including a low-alcohol beer) may be warranted.

## 207 **Conclusion**

208 The exclusive provision of calorie-containing drinks (compared to water) following exercise  
209 influences subsequent dietary intake, with minimal impact on next day hydration in recreational  
210 runners.

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