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### Original Citation

Harper, Liam D., Briggs, Marc A, McNamee, Ged, West, Daniel J, Kilduff, Liam P., Stevenson, Emma and Russell, Mark (2016) Physiological and performance effects of carbohydrate gels consumed prior to the extra-time period of prolonged simulated soccer match-play. *Journal of Science and Medicine in Sport*, 19 (6). pp. 509-514. ISSN 14402440

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1 **Title:** Physiological and performance effects of carbohydrate gels consumed prior to the extra-time  
2 period of prolonged simulated soccer match-play

3 **Running title:** Carbohydrate gel and extra-time

4

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**Title:** Physiological and performance effects of carbohydrate gels consumed prior to the extra-time period of prolonged simulated soccer match-play

**Running title:** Carbohydrate gel and extra-time

18 **Abstract**

19 *Objectives:* The physiological and performance effects of carbohydrate-electrolyte gels consumed  
20 before the 30 min extra-time period of prolonged soccer-specific exercise were investigated.

21 *Design:* Randomised, double-blind, crossover.

22 *Methods:* Eight English Premier League academy soccer players performed 120 min of soccer-  
23 specific exercise on two occasions while consuming fluid-electrolyte beverages before exercise, at  
24 half-time and 90 min. Carbohydrate-electrolyte ( $0.7 \pm 0.1 \text{ g}\cdot\text{kg}^{-1} \text{ BM}$ ) or energy-free placebo gels  
25 were consumed ~5 min before extra-time. Blood samples were taken before exercise, at half-time and  
26 every 15 min during exercise. Physical (15-m and 30-m sprint speed, 30-m sprint maintenance and  
27 countermovement jump height) and technical (soccer dribbling) performance was assessed throughout  
28 each trial.

29 *Results:* Carbohydrate-electrolyte gels improved dribbling precision ( $+29 \pm 20\%$ ) and raised blood  
30 glucose concentrations by  $0.7 \pm 0.8 \text{ mmol}\cdot\text{l}^{-1}$  during extra-time (both  $p < 0.01$ ). Supplementation did  
31 not affect sprint velocities (15-m and 30-m), 30-m sprint maintenance or dribbling speed as reductions  
32 compared to 0-15 min values occurred at 105-120 min irrespective of trial (all  $p < 0.05$ ). Plasma  
33 osmolality and blood sodium concentrations increased post-exercise versus the opening 15 min ( $p <$   
34  $0.05$ ) but no effect of supplementation existed. Selected markers of physical performance (jump  
35 height, 30-m sprint velocity and 30-m repeated sprint maintenance) also reduced by  $>3\%$  during half-  
36 time (all  $p < 0.05$ ).

37 *Conclusions:* Carbohydrate-electrolyte gel ingestion raised blood glucose concentrations and  
38 improved dribbling performance during the extra-time period of simulated soccer match-play.  
39 Supplementation did not attenuate reductions in physical performance and hydration status that  
40 occurred during extra-time.

41

42 *Keywords:* fatigue, football, skill, glucose, intermittent, hydration

43 **Introduction**

44 When scores are tied at the end of specific soccer tournament matches, a 30 min extra-time (ET)  
45 period is played. According to official match data ([www.FIFA.com](http://www.FIFA.com)), 22% and 35% of knockout  
46 phase matches played between 2002 and 2014 at U17 and senior FIFA World Cup competitions  
47 required ET, respectively. Given the importance of ET in soccer tournaments, the dearth of literature  
48 profiling, 1) the demands of this additional period of play, and 2) the effects of ergogenic  
49 interventions throughout 120 min of soccer-specific exercise, is surprising.

50 Reductions in performance capacity have been observed following intense periods of competition,<sup>1</sup>  
51 after a passive half-time period,<sup>2</sup> and during simulated and actual soccer match-play.<sup>3,4</sup> Although a  
52 topic of debate,<sup>5,6,7</sup> the mechanisms of reduced performance have primarily been attributed to  
53 physiological responses that are either central (i.e., central nervous system)<sup>5</sup> or peripheral (i.e.,  
54 disturbances in acid-base balance, blood glucose concentrations, muscle ion homeostasis, hydration  
55 status, muscle temperature and/or fibre-specific glycogen content) in origin.<sup>6,7,8</sup> Notably, the  
56 physiological effects of 120 min of soccer-specific exercise have not been reported despite indices of  
57 physical and skill performance reducing during ET.<sup>9,10</sup>

58 Ergogenic effects have been observed following provision of carbohydrates on physical and skilled  
59 actions performed throughout simulated soccer match-play.<sup>4,11,12</sup> Increased exogenous energy  
60 provision,<sup>14</sup> maintenance of blood glucose concentrations, and improved intermittent exercise  
61 capacity have been reported following carbohydrate gel ingestion.<sup>11,13</sup> Although the ingestion of  
62 carbohydrate gels prior to ET is common in professional soccer, the physiological and performance  
63 responses to this nutritional strategy are unknown.

64 Therefore, the aim of this study was to evaluate the physiological and performance responses to  
65 carbohydrate-electrolyte gels consumed before the ET period of a simulated soccer match. We  
66 hypothesised that carbohydrate provision would influence physiological and performance responses  
67 during ET.

## 68 **Methods**

69 This study received ethical approval from the Health and Life Sciences Ethics Committee at  
70 Northumbria University. Male soccer players recruited from an English Premier League club ( $n = 8$ ,  
71 age:  $16 \pm 1$  years, mass:  $68.5 \pm 5.3$  kg, stature:  $1.73 \pm 0.05$  m, estimated  $\dot{V}O_{2\max}$ :  $55 \pm 9$  ml·kg<sup>-1</sup>·min<sup>-1</sup>)  
72 provided written informed consent (and parental consent where players <18 years). Players trained for  
73 ~16 h per week and played for a professional academy for >12 months before the study started. Two  
74 main trials (carbohydrate: CHO and placebo: PLA), separated by  $9 \pm 4$  days, were completed using a  
75 double-blind, randomised, counterbalanced and cross-over design.

76

77 A preliminary visit included estimation of  $\dot{V}O_{2\max}$ <sup>15</sup> and procedural habituation, with main trials  
78 performed on two subsequent visits. Players performed a light 45 min training session (involving  
79 positional and tactic-specific drills), refrained from caffeine consumption and recorded all food  
80 consumed (analysed retrospectively; Nutritics Ltd., UK) in the 24 h preceding each main trial.  
81 Following an overnight fast, players arrived at 08:00 h and provided a mid-flow urine sample. A  
82 resting fingertip capillary blood sample was taken before players consumed a standardised breakfast  
83 (2079 kJ, 77.1 g carbohydrates, 12.3 g fats, and 14.3 g proteins) including 500 ml of a fluid-  
84 electrolyte beverage (Mineral Water, Highland Spring, UK). Body mass and stature (Seca GmbH &  
85 Co., Germany) were then measured.

86

87 A pre-exercise blood sample was taken after players rested for ~90 min following breakfast. A  
88 standardised warm-up (including multidirectional and linear speed drills, dynamic stretching and  
89 dribbling practice), during which players consumed 200 ml of the fluid-electrolyte beverage, was then  
90 performed. Performance testing (PT) preceded exercise, with countermovement jump (CMJ) height<sup>16</sup>  
91 and 30-m repeated sprint maintenance (RSM)<sup>17</sup> assessed. Players performed three CMJ's interspersed  
92 with 10 s passive recovery and three 30-m sprints with 25 s of active recovery. These assessments  
93 were repeated on a further four occasions (i.e., post-first half; P2, pre-second half; P3, post-second  
94 half; P4, post-exercise; P5).

95 Using a modified version of the Soccer Match Simulation (SMS),<sup>18</sup> participants performed 120 min  
96 of soccer-specific exercise; consisting of two 45 min halves and two additional 15 min periods (ET).  
97 The repeatability of the physiological and performance responses to the original SMS have been  
98 determined.<sup>19</sup> Directed by audio signals, the SMS required players to cover ~14.4 km (reflecting  
99 actual match-play requiring ET)<sup>10</sup> at various running intensities, with backwards and sideward  
100 movements over a 20-m distance, while intermittently performing 15-m timed sprints and 18-m ball  
101 dribbles (assessed for precision, percentage success, and average speed).<sup>4</sup> Participants were required  
102 to dribble a ball between cones as fast and as accurately as possible with a cone being unsuccessfully  
103 negotiated if touched by the ball or not completed in the required direction. Video footage (50 Hz;  
104 DCR-HC96E; Sony Ltd, UK) and digitisation (Kinovea version 0.8.15; Kinovea Org., France)  
105 techniques yielded speed (time taken to successfully complete the distance) and precision (distance of  
106 the ball from each cone) data. Dribbling performance was expressed as an average per 15 min of  
107 exercise (epochs; EM): 0-15 min (E1), 16-30 min (E2), 31-45 min (E3), 46-60 min (E4), 61-75 min  
108 (E5), 76-90 min (E6), 91-105 min (E7) and 106-120 min (E8).

109

110 A 15 min half-time (HT) passive recovery period, where players consumed 500 ml of a fluid-  
111 electrolyte beverage, separated the two 45 min halves. Five min of rest followed the end of normal  
112 time and a two min period separated each half of ET. Body mass assessment and gel consumption  
113 (with 300 ml of fluid-electrolyte beverage) preceded the start of ET. Gels were professionally  
114 manufactured and were taste and texture matched (IsoGel, High5 Ltd., UK). Sachets providing  $0.7 \pm$   
115  $0.1 \text{ g}\cdot\text{kg}^{-1}$  BM carbohydrates derived from glucose and maltodextrin (808 kJ; 46 g carbohydrates, 0 g  
116 fats, 0 g proteins, 0.14 g salt; CHO) or placebo (0 kJ; 0 g carbohydrates, fats and proteins 0.14 g salt;  
117 PLA) were consumed using a double-blind, randomised and counterbalanced design.

118

119 Fingertip capillary blood samples (170  $\mu\text{l}$ ) were collected at rest, P1, HT and at the end of each epoch  
120 (i.e., E1-E8) and analysed for blood glucose, lactate and sodium concentrations (GEM Premier 3000;  
121 Instrumentation Laboratory, UK; CV's: 0.6-2.2%).<sup>20</sup> Urine and plasma osmolality (Advanced Model  
122 3300 Micro-Osmometer; Advanced Instruments Inc., USA), urine-corrected mass changes, ratings of

123 perceived exertion (RPE) <sup>21</sup> and abdominal discomfort (AD; similar to the methods of: <sup>22</sup>) were  
124 recorded during each trial. Environmental conditions were measured during exercise (Technoline  
125 WS-9032; Technotrade GmbH, Germany) and heart rate (HR) was recorded (Polar RS400; Polar  
126 Electro, Finland). A mid-flow urine sample was collected post-exercise and body mass was measured.  
127 Statistical analyses were carried out using SPSS Statistics software (IBM Inc., USA) with significance  
128 set at  $p \leq 0.05$ . Data are reported as mean  $\pm$  standard deviation (SD). Statistical power was calculated  
129 using commercially available software (GPower v3.1, Germany) and a sample size of eight was  
130 deemed sufficient for  $>80\%$  power to detect statistical differences in blood glucose and dribbling  
131 precision. For parametric data (confirmed by normality and variance assessments), paired sample t-  
132 tests were performed for single time-point data. For parametric data expressed over multiple time-  
133 points, two-way repeated measures analysis of variance (within-participant factors: treatment x time)  
134 were performed. Where significant interactions were observed, supplementation was deemed to have  
135 influenced responses and simple main effects were performed. Partial eta-squared ( $\eta^2$ ) values were  
136 calculated and LSD corrected *post-hoc* tests (with 95% Confidence Intervals; CI) with Cohen's *d*  
137 calculations examined between-trial differences. Non-parametric data were analysed using a Friedman  
138 test with *post-hoc* Wilcoxon Signed Ranks tests (ES calculated using the Z distribution value) to  
139 identify effects. <sup>23</sup> For effect size data, thresholds of 0.2, 0.5, and 0.8 were considered small, medium  
140 and large, respectively. <sup>23</sup>



141 **Results**

142 Ambient temperature ( $18.5 \pm 1.5^\circ\text{C}$ ), humidity ( $74 \pm 7\%$ ) and barometric pressure ( $1017 \pm 3$  mmHg)  
143 were similar between trials ( $p > 0.05$ ). Players reported to each trial in a similar hydration state  
144 (plasma osmolality:  $312 \pm 6$  mOsmol $\cdot\text{kg}^{-1}$ ,  $p = 0.936$ ). Energy intake ( $8.6 \pm 0.7$  MJ $\cdot\text{d}^{-1}$ ) and  
145 macronutrient content (carbohydrate, fats, proteins:  $3.7 \pm 0.4$ ,  $2.7 \pm 0.8$ ,  $2.2 \pm 0.3$  MJ $\cdot\text{d}^{-1}$ , respectively)  
146 was similar across trials ( $p > 0.05$ ).

147 Supplementation influenced mean dribbling precision ( $p = 0.015$ ,  $\eta^2 = 0.287$ ) with dribbles performed  
148 during E8 being  $29 \pm 20\%$  more accurate in CHO than PLA ( $p = 0.014$ ,  $d = 1.3$ , CI: 3.2-21.0 cm;  
149 Figure 1A). Dribbles were also more accurate during E5 in CHO than PLA ( $p = 0.002$ ,  $d = 1.0$ , CI:  
150 3.8-11.3 cm; Figure 1A). Although dribbling speed ( $p = 0.671$ ,  $\eta^2 = 0.091$ ) and success ( $p = 0.677$ ,  $\eta^2$   
151  $= 0.070$ ) were not affected by supplementation (Figure 1C), dribbling speed was lower ( $p < 0.001$ ,  $\eta^2$   
152  $= 0.500$ ) during E7 and E8 compared to E1 ( $-12.3 \pm 3.8\%$ ,  $-10.1 \pm 6.6\%$ , respectively, both  $p < 0.001$ )  
153 (Figure 1B). Dribbles in E8 were  $4.6 \pm 5.9\%$  slower than E6 ( $p = 0.046$ ) and  $5.7 \pm 4.7\%$  slower during  
154 E6 versus E1 ( $p = 0.012$ ) (Figure 1B).

155 Supplementation did not influence 15- or 30-m sprint velocities ( $p = 0.772$ ,  $\eta^2 = 0.044$  and  $p = 0.599$ ,  
156  $\eta^2 = 0.091$ , respectively). Likewise, 30-m RSM and CMJ height were similar between trials ( $p =$   
157  $0.528$ ,  $\eta^2 = 0.104$  and  $p = 0.389$ ,  $\eta^2 = 0.133$ , respectively). However, exercise influenced these  
158 variables ( $p < 0.001$ ,  $\eta^2 = 0.640$ ;  $p < 0.001$ ,  $\eta^2 = 0.501$ ;  $p < 0.001$ ,  $\eta^2 = 0.527$  and  $p = 0.053$ ,  $\eta^2 = 0.370$ ,  
159 respectively). Sprint velocities over 15-m reduced during E7 ( $5.52 \pm 0.57$  m $\cdot\text{s}^{-1}$ ) and E8 ( $5.37 \pm 0.56$   
160 m $\cdot\text{s}^{-1}$ ) when compared to E1 ( $5.92 \pm 0.47$  m $\cdot\text{s}^{-1}$ ) (both  $p < 0.01$ ) and during E8 compared to E6 ( $5.63 \pm$   
161  $0.58$  m $\cdot\text{s}^{-1}$ ) ( $p = 0.001$ ). Sprint velocities over 30-m ( $-4 \pm 2\%$ ,  $p = 0.003$ ) and RSM scores ( $-4 \pm 3\%$ ,  $p$   
162  $= 0.003$ ) were lower at P5 versus P1 (Table 2). Decrements between E6 and E1 existed for 15-m  
163 sprint velocities ( $-5 \pm 4\%$ ,  $p = 0.010$ ) and between P4 and P1 for 30-m sprint velocities ( $-3 \pm 3\%$ ,  $p =$   
164  $0.036$ ) and 30-m RSM ( $-3 \pm 3\%$ ,  $p = 0.018$ ) (Table 2). Compared to other time-points, CMJ height  
165 was not different at P5, however; CMJ height, 30-m sprint velocities and 30-m RSM were dampened  
166 at P3 compared to both P1 ( $-7 \pm 4\%$ ,  $-4 \pm 2\%$ ,  $-5 \pm 3\%$ , respectively, all  $p < 0.05$ ) and P2 ( $-5 \pm 4\%$ ,  $-3$   
167  $\pm 3\%$ ,  $-3 \pm 3\%$ , respectively, all  $p < 0.05$ ) (Table 2).

168 Supplementation did not influence RPE ( $p = 0.623$ ,  $\eta^2 = 0.098$ ), however; timing effects were present  
169 ( $p < 0.001$ ,  $\eta^2 = 0.858$ ), with significantly higher RPE values during E7 ( $15 \pm 3$ ) and E8 ( $17 \pm 3$ )  
170 compared to E1 ( $11 \pm 3$ ) and E6 ( $14 \pm 3$ ) (all  $p < 0.01$ ). Similarly, increases were found in RPE during  
171 E6 versus E1 ( $p < 0.001$ ). The pattern of response for mean HR ( $HR_{\text{mean}}$ ) was not influenced by  
172 supplementation ( $p = 0.852$ ,  $\eta^2 = 0.023$ ) or exercise ( $p = 0.086$ ,  $\eta^2 = 0.297$ ).

173 Both supplementation ( $p = 0.026$ ,  $\eta^2 = 0.354$ ) and exercise ( $p < 0.001$ ,  $\eta^2 = 0.656$ ) influenced blood  
174 glucose concentrations with CHO values being  $16 \pm 17\%$  greater than PLA during E7 ( $5.6 \pm 0.9$   
175  $\text{mmol l}^{-1}$  vs.  $4.6 \pm 0.2 \text{ mmol l}^{-1}$ ,  $p = 0.028$ ,  $d = 4.2$ , CI:  $0.18\text{-}1.93 \text{ mmol l}^{-1}$ ) (Table 1). Supplementation  
176 did not affect blood lactate or sodium concentrations ( $p = 0.188$ ,  $\eta^2 = 0.208$  and  $p = 0.282$ ,  $\eta^2 = 0.162$ ,  
177 respectively) but exercise did ( $p = 0.006$ ,  $\eta^2 = 0.500$ , and  $p < 0.001$ ,  $\eta^2 = 0.583$ , respectively) (Table  
178 1). During E7, blood lactate concentrations were lower than E1 ( $-94 \pm 57\%$ ,  $p = 0.004$ ) and E6 ( $-25 \pm$   
179  $25\%$ ,  $p = 0.048$ ). Blood lactate was also lower during E6 versus E1 ( $-32 \pm 17\%$ ,  $p = 0.001$ ) (Table 1).  
180 Blood sodium concentrations were  $1.6 \pm 1.9\%$  higher during E8 compared to E1 ( $p = 0.045$ ) and  $1.0 \pm$   
181  $0.7\%$  higher during E7 compared to E1 ( $p = 0.005$ ) (Table 1). Blood sodium concentrations were  
182 similar at E6 and E1 ( $p > 0.05$ ) (Table 1).

183 Urine osmolality was similar between treatments ( $p = 0.716$ ,  $\eta^2 = 0.020$ ) remaining unchanged from  
184 pre- to post-exercise in both trials ( $-10 \pm 37\%$ ,  $p = 0.391$ ). Supplementation did not affect plasma  
185 osmolality ( $p = 0.936$ ,  $\eta^2 = 0.001$ ) or body mass ( $p = 0.913$ ,  $\eta^2 = 0.003$ ); however, post-exercise  
186 plasma osmolality was  $7 \pm 4\%$  greater ( $p < 0.001$ ,  $\eta^2 = 0.882$ ) than pre-exercise ( $332 \pm 8$  vs.  $312 \pm 6$   
187  $\text{mOsmol kg}^{-1}$ ,  $p < 0.001$ ). Post-exercise body mass ( $67.8 \pm 4.7 \text{ kg}$ ) was reduced ( $p < 0.001$ ,  $\eta^2 = 0.921$ )  
188 compared to resting ( $69.4 \pm 5.0 \text{ kg}$ ;  $p < 0.001$ ) and P4 values ( $68.2 \pm 4.8 \text{ kg}$ ;  $p = 0.001$ ).  
189 Supplementation did not affect AD ( $p > 0.05$ ), but exercise did ( $p < 0.001$ ); with E8 ( $5 \pm 3$ ) and E7 ( $5$   
190  $\pm 3$ ) values being greater than E1 ( $2 \pm 1$ ) ( $p < 0.05$ ,  $r = 0.8$  for both). During E6, AD was higher  
191 compared to E1 ( $p = 0.024$ ,  $r = 0.8$ ).

192 **Discussion**

193 This is the first study to examine the physiological and performance effects of carbohydrate-  
194 electrolyte gels consumed prior to the ET period in soccer. In agreement with our hypotheses,  
195 increased blood glucose concentrations and improved dribbling precision occurred during ET in CHO.  
196 Additionally, we observed reductions in physical performance throughout 120 min of soccer-specific  
197 exercise with evidence highlighting further performance reductions during ET compared to the end of  
198 normal time. Therefore, consumption of carbohydrate-electrolyte gels offers an ergogenic strategy for  
199 players preparing to engage in an ET period, however; not all performance decrements were  
200 ameliorated by carbohydrate provision.

201 Improved skill performance (i.e., shot velocity and success) has been observed following  
202 carbohydrate ingestion.<sup>4, 12</sup> However, the efficacy of carbohydrate provision is unknown when 120  
203 min of soccer-specific exercise is performed. In eight professional academy soccer players, a  $0.7 \pm 0.1$   
204  $\text{g}\cdot\text{kg}^{-1}$  BM dose of carbohydrate raised blood glucose concentrations by  $16 \pm 17\%$  (large effect;  $d =$   
205  $4.2$ ; Table 1) and resulted in a  $29 \pm 20\%$  improvement (large effect;  $d = 1.3$ ; Figure 1A) in dribbling  
206 precision throughout E8. Although we found an unexplainable difference prior to carbohydrate  
207 ingestion (Figure 1), improved performance of sports skills following carbohydrate consumption has  
208 previously been associated with enhanced cerebral glucose supply and preserved central nervous  
209 system integrity,<sup>24, 25</sup> even when participants remain euglycaemic.<sup>4</sup> Additionally, elevated blood  
210 glucose concentrations induce muscle glycogen sparing,<sup>14</sup> augmented neuromuscular function,<sup>24</sup>  
211 attenuated central fatigue *via* serotonergic neurotransmitter release<sup>12</sup> and modified motor output  
212 resulting from stimulation of afferent brain signals *via* oropharyngeal receptor activation.<sup>26</sup> Although  
213 the precise mechanisms of skill performance regulation have yet to be delineated and are likely  
214 multifaceted in origin, our data expands the findings of previous studies that have observed enhanced  
215 skill performance with carbohydrate supplementation<sup>4, 12</sup> by demonstrating ergogenic effects of  
216 carbohydrate ingested prior to ET on dribbling precision.

217 Ostensibly, additional fatigue occurs throughout ET as further diminutions in performance were  
218 observed after 90 min (Table 2). This finding is corroborated by observations that further reductions  
219 in high-intensity distance covered and accelerations occur throughout ET.<sup>10</sup> Moreover, concomitant  
220 increases in RPE, a subjective marker of exercise intensity, occurred after 90 min. Notably, the  
221 supplementation strategy used in this study did not attenuate the physical performance decrements  
222 observed throughout 120 min of soccer-specific exercise. Future research opportunities therefore exist  
223 to optimise the hydro-nutritional strategies of players competing in matches requiring ET. In  
224 agreement with previous authors,<sup>27, 28</sup> we observed deleterious effects of a passive HT recovery  
225 period on CMJ height, 30-m sprint velocities and RSM (Table 2). Therefore, the efficacy of  
226 intervention strategies administered over HT also warrants further investigation.<sup>28</sup>

227 Temporal match-related fatigue development is a complex phenomenon, with a multitude of putative  
228 factors,<sup>7</sup> including depletion of endogenous fuel stores,<sup>8</sup> compromised excitation-contraction  
229 coupling,<sup>7</sup> and dehydration.<sup>29</sup> Logistical constraints prevented the assessment of each of these  
230 factors in isolation in the current investigation. Nevertheless, the timings of fluid and treatment  
231 ingestion were reflective of the hydro-nutritional practices of professional players.<sup>29</sup> In ambient  
232 conditions, a  $1.6 \pm 0.6\%$  BM loss at P4 indicates that provision of a fluid-electrolyte beverage with  
233 breakfast, during the warm-up and at HT was sufficient to prevent reductions in mass losses that  
234 exceed 2%; a threshold commonly associated with onset of reduced performance.<sup>29</sup> However, ET  
235 elicited a further  $0.5 \pm 0.3$  kg mass loss as well as increases in plasma osmolality and blood sodium  
236 concentrations (Table 1); possibly indicating compromised hydration status. This may be partly due to  
237 slower gastric emptying and/or intestinal absorption, as highlighted by elevated abdominal discomfort  
238 scores during ET compared to the first 90 min of exercise.<sup>11</sup> Such changes are likely components of a  
239 milieu of factors contributing to match-related fatigue and highlight the need for further research to  
240 optimise the hydro-nutritional strategies of players involved in 120 min of soccer-specific exercise.

## 241 **Conclusions**

242 Providing carbohydrate gel ( $0.7 \pm 0.1 \text{ g}\cdot\text{kg}^{-1} \text{ BM}$ ) before ET increased blood glucose concentrations  
243 and improved dribbling precision thereafter but this intervention did not appear to benefit physical  
244 performance indices which reduced throughout 120 min of exercise. Alterations in dribbling  
245 performance can influence the outcome a match,<sup>30</sup> highlighting the potential benefits of carbohydrate  
246 provision prior to ET. Moreover, ET caused additional perturbations in physical and physiological  
247 responses compared to the previous 90 min. Therefore, given the role of ET in determining  
248 tournament progression, further work is needed to develop intervention strategies that attempt to  
249 preserve physical performances throughout 120 min of soccer-specific exercise.

250

## 251 **Practical Implications**

- 252 • Strategies (e.g., nutritional interventions, training programme design, tactical changes etc.)  
253 that enable soccer players to cope with the additional demands of the extra-time period are  
254 recommended
- 255 • Provision of  $0.7 \pm 0.1 \text{ g}\cdot\text{kg}^{-1} \text{ BM}$  of carbohydrate (in gel form) prior to the soccer extra-time  
256 period provides an ergogenic strategy for augmented technical (i.e., dribbling precision), but  
257 not physical (i.e., sprinting and jumping ability), performance
- 258 • Half-time intervention strategies warrant investigation as a passive half-time recovery period  
259 elicited reductions in subsequent jump and sprint performance

260

## 261 **Acknowledgements**

262 The authors would like to thank the players and coaches of Sunderland AFC for their co-operation  
263 and efforts during the study. The authors are also grateful to High5 Ltd. for providing the gels used in  
264 this research and to Mr. Tom Clifford, Mr. Dean Allerton and Ms. Meghan Brown for their assistance  
265 during data collection. No financial assistance was provided for this study.

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**Table 1** Blood metabolite data as a function of timing and trial

Variable	Trial	Timing										
		Rest	Pre	E1	E2	E3	HT	E4	E5	E6	E7	E8
Glucose (mmol·l <sup>-1</sup> )	CHO	5.0 ± 0.6	5.7 ± 0.6	5.1 ± 0.5	4.7 ± 0.5	4.8 ± 0.4	4.5 ± 0.6	4.3 ± 0.4	4.3 ± 0.2	4.5 ± 0.5	5.6 ± 0.9 <sup>a</sup>	5.0 ± 0.6
	PLA	4.9 ± 0.3	5.7 ± 0.5	4.9 ± 0.3	4.7 ± 0.3	4.7 ± 0.3	4.8 ± 0.4	4.6 ± 0.2	4.6 ± 0.4	4.5 ± 0.4	4.6 ± 0.2	4.7 ± 0.5
Lactate (mmol·l <sup>-1</sup> )	CHO	0.8 ± 0.2	1.4 ± 0.5	5.1 ± 3.1	3.7 ± 3.6	4.8 ± 3.3	3.0 ± 1.1	3.9 ± 3.3	4.0 ± 2.7	3.4 ± 2.7	2.4 ± 1.8	2.9 ± 2.2
	PLA	0.7 ± 0.2	1.6 ± 0.7	3.4 ± 1.6	3.0 ± 1.2	3.1 ± 1.7	2.4 ± 0.5	2.4 ± 0.7	2.3 ± 0.7	2.4 ± 1.0	2.2 ± 0.7	3.3 ± 2.2
Sodium (mmol·l <sup>-1</sup> )	CHO	138 ± 2	139 ± 1	141 ± 0	142 ± 1	143 ± 2	142 ± 2	142 ± 1	143 ± 1	142 ± 4	142 ± 1	143 ± 3
	PLA	139 ± 1	140 ± 1	141 ± 1	143 ± 1	143 ± 2	141 ± 2	140 ± 2	141 ± 1	143 ± 3	142 ± 1	144 ± 3

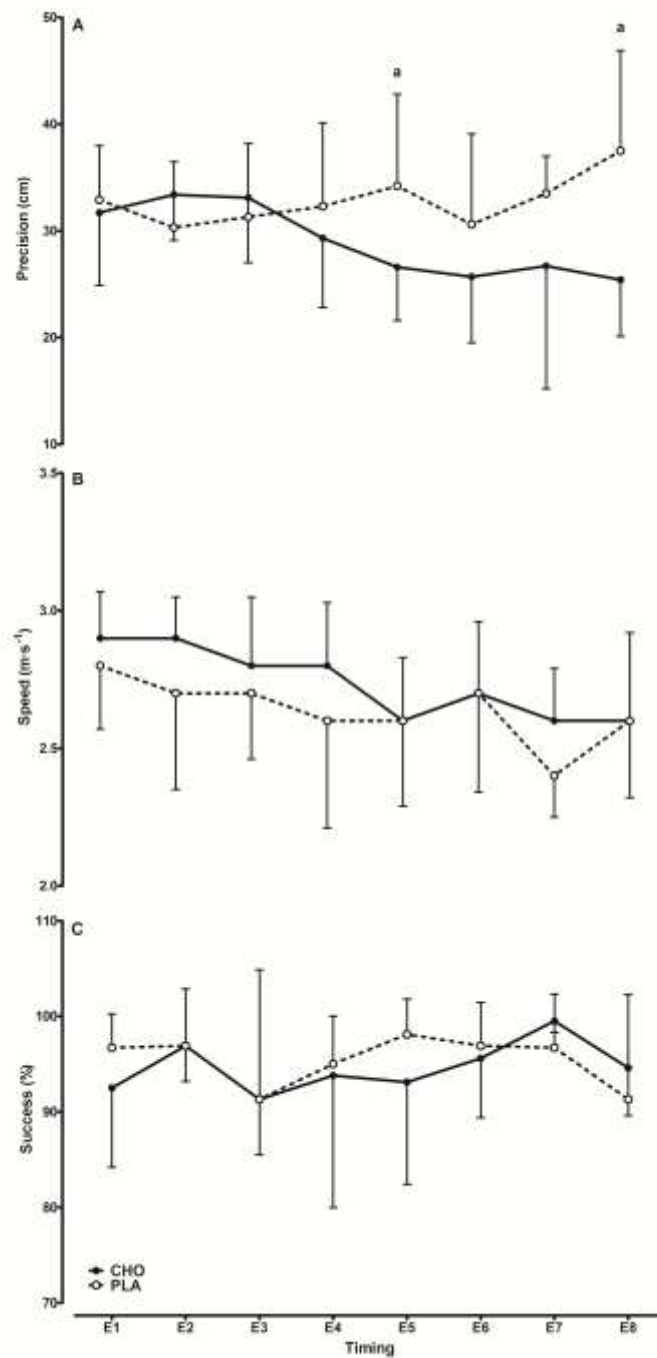
Pre represents pre-exercise and E1-8 represents 0-15, 16-30, 31-45, 46-60, 61-75, 76-90, 91-105 and 106-120 min respectively. HT represents half-time. CHO = carbohydrate-electrolyte gel trial, PLA = placebo gel trial. a = significant difference between trials ( $p < 0.05$ ). Data presented as mean ± SD.

**Table 2** Performance variables as a function of timing and trial

Variable	Trial	Timing				
		P1	P2	P3	P4	P5
<b>30-m Sprint Velocities (m·s<sup>-1</sup>)</b>	CHO	6.95 ± 0.25	6.80 ± 0.23	6.61 ± 0.33	6.70 ± 0.31	6.76 ± 0.19
	PLA	6.97 ± 0.31	6.92 ± 0.16	6.72 ± 0.30	6.83 ± 0.34	6.63 ± 0.51
<b>30-m Repeated Sprint Maintenance (%)</b>	CHO	99 ± 1	96 ± 4	93 ± 6	95 ± 4	96 ± 3
	PLA	98 ± 1	98 ± 2	94 ± 5	96 ± 4	93 ± 7
<b>CMJ Height (cm)</b>	CHO	34.5 ± 3.2	33.9 ± 2.8	32.3 ± 3.2	33.5 ± 2.5	33.8 ± 2.5
	PLA	35.5 ± 3.7	35.2 ± 4.4	33.2 ± 3.9	35.6 ± 5.0	33.8 ± 6.2

P1-5 represents pre-exercise, post-first half, pre-second half, post-second half and post-exercise, respectively. CMJ = countermovement jump. CHO = carbohydrate-electrolyte gel trial, PLA = placebo gel trial. Data presented as mean ± SD.

## Figure Legends



**Figure 1** Dribbling precision (A), speed (B) and success (C) throughout each trial (mean  $\pm$  SD). E1-8 represents 0-15, 16-30, 31-45, 46-60, 61-75, 76-90, 91-105 and 106-120 min respectively and HT represents half-time. a = significant difference between CHO and PLA ( $p < 0.05$ ) at corresponding time-point.