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

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ABSTRACT

Objectives: The physiological and performance effects of carbohydrate-electrolyte gels consumed before the 30 min extra-time period of prolonged soccer-specific exercise were investigated.
Design: Randomised, double-blind, crossover.
Methods: Eight English Premier League academy soccer players performed 120 min of soccer-specific exercise on two occasions while consuming fluid-electrolyte beverages before exercise, at half-time and 90 min. Carbohydrate–electrolyte (0.7 ± 0.1 g kg^{-1} BM) or energy-free placebo gels were consumed ~5 min before extra-time. Blood samples were taken before exercise, at half-time and every 15 min during exercise. Physical (15-m and 30-m sprint speed, 30-m sprint maintenance and countermovement jump height) and technical (soccer dribbling) performance was assessed throughout each trial.
Results: Carbohydrate–electrolyte gels improved dribbling precision (+29 ± 20%) and raised blood glucose concentrations by 0.7 ± 0.8 mmol l^{-1} during extra-time (both $p < 0.01$). Supplementation did not affect sprint velocities (15 m and 30 m), 30-m sprint maintenance or dribbling speed as reductions compared to 0–15 min values occurred at 105–120 min irrespective of trial (all $p < 0.05$). Plasma osmolality and blood sodium concentrations increased post-exercise vs. the opening 15 min ($p < 0.05$) but no effect of supplementation existed. Selected markers of physical performance (jump height, 30-m sprint velocity and 30-m repeated sprint maintenance) also reduced by >3% during half-time (all $p < 0.05$).
Conclusions: Carbohydrate–electrolyte gel ingestion raised blood glucose concentrations and improved dribbling performance during the extra-time period of simulated soccer match-play. Supplementation did not attenuate reductions in physical performance and hydration status that occurred during extra-time.

1. Introduction

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

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

Ergogenic effects have been observed following provision of carbohydrates on physical and skilled actions performed throughout

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simulated soccer match-play. [4,11,12] Increased exogenous energy provision, [14] maintenance of blood glucose concentrations, and improved intermittent exercise capacity have been reported following carbohydrate gel ingestion. [11,13] Although the ingestion of carbohydrate gels prior to ET is common in professional soccer, the physiological and performance responses to this nutritional strategy are unknown.

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

2. Methods

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

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

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

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

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

Fingertip capillary blood samples (170 μl) were collected at rest, P1, HT and at the end of each epoch (i.e., E1–E8) and analysed for blood glucose, lactate and sodium concentrations (GEM Premier 3000; Instrumentation Laboratory, UK; CV's: 0.6–2.2%). [20] Urine and plasma osmolality (Advanced Model 3300 Micro-Osmometer; Advanced Instruments Inc., USA), urine-corrected mass changes, ratings of perceived exertion (RPE) [21] and abdominal discomfort (AD; similar to the methods of: [22]) were recorded during each trial. Environmental conditions were measured during exercise (Technoline WS-9032; Technotrade GmbH, Germany) and heart rate (HR) was recorded (Polar RS400; Polar Electro, Finland). A mid-flow urine sample was collected post-exercise and body mass was measured.

Statistical analyses were carried out using SPSS Statistics software (IBM Inc., USA) with significance set at $p \leq 0.05$. Data are reported as mean ± standard deviation (SD). Statistical power was calculated using commercially available software (GPower v3.1, Germany) and a sample size of eight was deemed sufficient for >80% power to detect statistical differences in blood glucose and dribbling precision. For parametric data (confirmed by normality and variance assessments), paired sample *t*-tests were performed for single time-point data. For parametric data expressed over multiple time-points, two-way repeated measures analysis of variance (within-participant factors: treatment × time) were performed. Where significant interactions were observed, supplementation was deemed to have influenced responses and simple main effects were performed. Partial eta-squared (η^2) values were calculated and LSD corrected *post-hoc* tests (with 95% Confidence Intervals; CI) with Cohen's *d* calculations examined between-trial differences. Non-parametric data were analysed using a Friedman test with *post-hoc* Wilcoxon Signed Ranks tests (ES calculated using the *Z* distribution value) to identify effects. [23] For effect size data, thresholds of 0.2, 0.5 and 0.8 were considered small, medium and large, respectively. [23]

3. Results

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