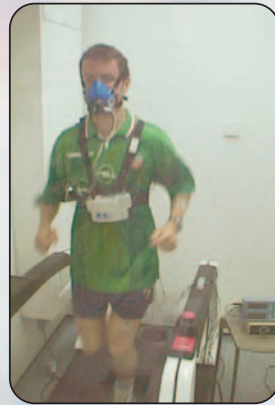


ENHANCED RUNNING PERFORMANCE WITH REPEATED CARBOHYDRATE-FLUID INGESTION DURING EXERCISE IN THE HEAT.

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The aim of this study was to evaluate the effects of different fluid-carbohydrate (CHO) replacement regimens on simulated laboratory soccer performance in a hot and humid environment (35 °C, 50% r.h.). On two occasions separated by 7-d, seven trained male university soccer players (mass 77.0 ±6.1 kg; VO_{2peak}: 59.1 ±8.1 ml·kg⁻¹·min⁻¹) performed a paced 90-min effort of variable intensity



INTRODUCTION

- International soccer is frequently played under hot and humid conditions which are not the players NORMAL training or competitive environment (e.g World Club Championships, Rio, Brazil, 1999)
- FIFA regulations currently restrict the availability of beverages during the normal course of the soccer match to consumption pre game and half time.
- This amount may be inadequate for rehydration, even under thermoneutral conditions, and it is proposed regular carbohydrate and fluid feedings should be available during the course of the game.
- The aim of this study was to evaluate the effects of different fluid-carbohydrate (CHO) replacement regimens on simulated laboratory soccer performance in a hot and humid environment (35 °C, 50% r.h.).

METHODS

Subjects:

Seven male university level soccer players participated in this investigation. (See Table 1).

	Age (yr)	Weight (kg)	Height (m)	VO _{2peak} (L·min ⁻¹)
Mean	24.6	77.0	1.82	59.1
SD	5.3	6.1	0.03	8.1

TABLE 1: Subject Characteristics

Preliminary Testing:

- Prior to an experiment each subject performed a maximal incremental test to exhaustion on a motorised treadmill for the determination of peak oxygen uptake, heart rate and peak treadmill speed.
- Testing commenced at 10 km·h⁻¹, and running speed was increased by 0.5 km·h⁻¹ every 30 s until subjects reached volitional fatigue.
- Treadmill gradient was maintained at 1 % for the duration of the maximal test.
- All maximal tests were conducted under thermoneutral conditions (21 °C and 31% r.h.)
- Pre-Trial Familiarisation:**
 - Subjects were required to undertake 15 min of variable speed running on the treadmill to become accustomed to the level of intensity and changing speeds employed by the experimental protocol.
- Experimental Trials:**
 - All experimental trials were conducted in an environmental chamber with temperature maintained at 35 °C and relative humidity of 50%.
 - On two occasions separated by 7-d, subjects performed a paced 90-min effort of variable intensity running, this was followed immediately by 15-min of self-paced running (Figure 1).
 - Each paced effort consisted of repeated 5-min bouts, comprising 16 stages of variable intensity (0 - 22 km·h⁻¹) running to simulate work rates of trained soccer players (Table 2).

Activity Type	Duration (s)	Cumulative Duration (s)	Running Speed (km·h ⁻¹)
Walking	20	20	6
Jogging	20	40	8
Low speed running	15	55	12
Moderate speed running	10	65	15
Walking	30	95	6
Standing	30	125	0
Jogging	10	135	8
Low speed running	13	148	12
High speed running	6	154	17
Sprinting	9	163	22
Walking	30	193	6
Jogging	20	213	8
Moderate speed running	10	223	15
Walking	41	264	6
Low speed running	16	280	12
Standing	20	300	0

TABLE 2: The duration and intensity of each of the 16 steps within each five minute cycle of the treadmill protocol

running. Each paced run consisted of repeated 5-min efforts, comprising 16 stages of variable intensity (0 - 22 km·h⁻¹) running on a Powerjog Treadmill, to simulate work rates of trained soccer players. After 9 exercise cycles (45-min) subjects rested for 15-min before beginning a further 6 cycles of running (30-min). Finally, 15-min of self-paced running was undertaken as a performance measure.

During the trials subjects received a random order of either restricted fluid (RF) or fluid replacement (F). RF consisted of 5 ml·kg⁻¹ BM of a 5% CHO solution consumed 5-min prior to the trial and at half time (after 45-min running), in accordance with the laws of the International Football Association Board, 1998. F included an additional 5 feedings of 2 ml·kg⁻¹ BM of the same solution during exercise at regular (15-min) intervals. Subjects were able to run further in the self-paced performance trial following F (2.82 ±0.85 vs. 2.60 ±0.89 km, P<0.01). Although there were no differences in sweat loss between trials, BM loss was lower in F (0.9 ±0.5 vs. 1.8 ±0.7%, P<0.01). Mean skin temperature was lower in F during the paced 90-min (34.96 ±0.32 vs. 35.69 ±0.49 °C, P<0.05) and 15-min performance run (35.61 ±0.19 vs. 36.66 ±0.15 °C, P<0.05), while rectal temperature was lower during the performance section of F (39.12 ±0.31 vs. 39.36 ±0.26 °C, P<0.05). We conclude that ingestion of a carbohydrate beverage at regular (15 min) intervals enhances performance of variable intensity exercise in the heat by attenuating the rise in body temperature.

- After 9 exercise cycles (45-min) subjects rested in a thermoneutral environment for 15-min before beginning a further 6 cycles of running (30-min) (Figure 1).
- During the trials subjects received a random order of either restricted fluid (RF) or fluid replacement (F).
- RF consisted of 5 ml·kg⁻¹ BM of a 5% CHO solution consumed 5-min prior to the trial and at half time (after 45-min running), in accordance with the laws of the International Football Association Board, 1998. (Figure 1, green arrows only).
- F included an additional 5 feeding of 2 ml·kg⁻¹ BM of the same solution during exercise at regular (15-min) intervals. (Figure 1, green and blue arrows).

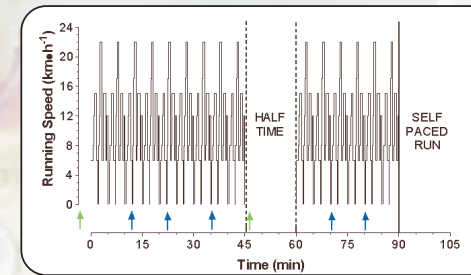


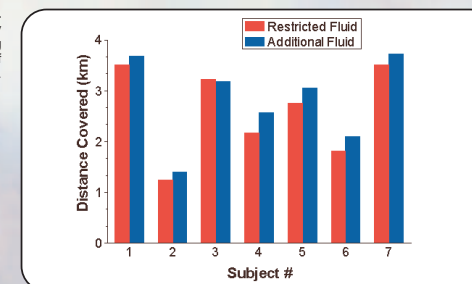
FIGURE 1. Schematic showing the changes in running speed to simulate a soccer match. After 45 min of running a half time period (denoted by vertical dashed lines) was given. During the final 15 min of the second half (denoted by solid vertical line) players were required to run as far as possible. Green arrows indicate players in F and RF trial received 5 ml·kg⁻¹ BM of 5% CHO solution. Blue arrows indicated that in F trial players received an additional 2 ml·kg⁻¹ BM of 5% CHO solution.

- During experimental trials rectal temperature (T_r) and four site skin temperature (T_{sk}) was monitored continuously, and recorded every 5-min.
- Additionally, experimental control was maintained by replicating "pre-match" diet and exercise prior to each trial.

RESULTS

- The total distance covered by each athlete in the 90 min paced effort was 9.39 km, at an average speed of 7.51 km·h⁻¹.
- Figure 2 shows the distance covered by each subject in the 15 min self paced section of the trial.
- All subjects were able to run further in the self-paced performance trial following F (2.82 ±0.85 vs. 2.60 ±0.89 km, P<0.01).

FIGURE 2. Distance covered by each subject during the 15 min self paced effort.



- Figure 3 shows sweat loss (change in body mass + fluid intake - urine loss) for each individual subject for the duration of the 105 min efforts.
- Mean sweat loss for the trials were 2.10 ±0.54 L for RF, and 2.24 ±0.42 L for F.
- There were no significant differences in sweat loss between trials.

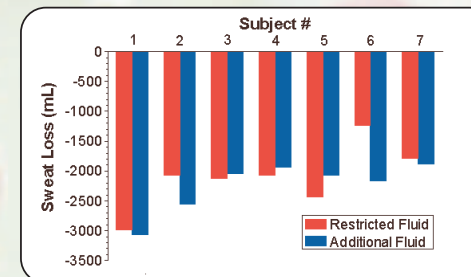


FIGURE 3. Sweat lost (mL) by each subject during the whole of the 105 min effort under restricted fluid, and additional fluid conditions.

- Figure 4 shows body mass loss (pre trial mass - post trial mass) for each individual subject for the duration of the experimental trials.
 - Body mass lost for the RF trial was 1.33 ±0.55 kg, which was significantly greater than body mass lost in the F trial (0.70 ±0.37 kg, P<0.005).
 - The percentage change in BM of 0.9 ±0.5 % in the F trial versus 1.8 ±0.7% for RF trial, (P<0.01).

- Figure 5 shows mean skin temperature (T_{sk}) during F and RF trials.
- Despite a no significant difference in T_{sk} at rest, T_{sk} rose rapidly during the RF trial, whilst in F T_{sk} appeared to plateau to 35 min before rising slowly.

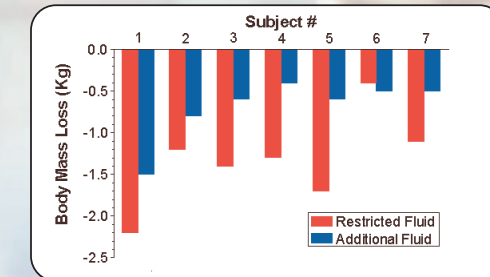
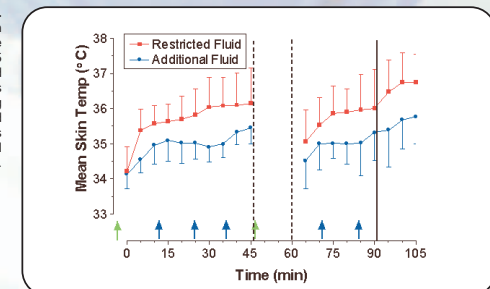


FIGURE 4. Change in body mass (kg) for each subject during experimental trials.

- During the simulated second half a similar pattern of increase in temperature also occurred.
- Mean skin temperature was significantly lower in F during the paced 90-min (34.96 ±0.32 vs. 35.69 ±0.49 °C, P<0.05)

- The rate of rise of T_{sk} was also greater for RF in the performance trial.
- This resulted in a significantly higher T_{sk} for RF during the 15-min performance run (35.61 ±0.19 vs. 36.66 ±0.15 °C, P<0.05)

FIGURE 5. Mean skin temperature for the 90 min paced, and 15 min self paced efforts. Green arrows indicated feeding during RF and F trials, blue arrows indicate additional feeding in F trial.



- Figure 6 illustrates mean rectal temperature (T_r) for the duration of the experimental trials.
- Rectal temperature rose steadily from rest during the first 45 min half in both trials. In the first 30 min of the second half, T_r was slightly lower during the F trial, although this did not reach significance.
- Despite subjects covering a further distance during the performance section of F, T_r was significantly lower for the 15-min effort (39.12 ±0.31 vs. 39.36 ±0.26 °C, P<0.05 for F and RF respectively).

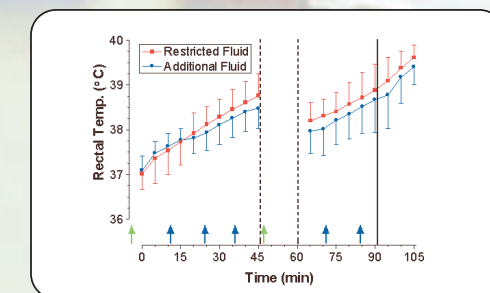


FIGURE 6. Mean rectal temperature for the 105 min in the two experimental trials. Green arrows indicated feeding during RF and F trials, blue arrows indicate additional feeding in F trial.

CONCLUSION

- We conclude that ingestion of an additional five carbohydrate beverage of 2 ml·kg⁻¹ BM at regular (15 min) intervals enhances self-paced running performance following a bout of variable intensity exercise in the heat by attenuating the rise in body temperature.