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TITLE

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Commercial Sport Drinks versus Light Meal Combat Rations: Effect on Simulated Combat Maneuvers

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This study compared a light meal combat ration (LMCR) to specific commercial sport drinks (CSD) and the effect of their ingestion on time to exhaustion during simulated combat maneuvers (SCM). The SCM consisted of three activities: a 2-hour march at 50% of maximal aerobic capacity ($\dot{V}O_{2max}$); a subsequent 1-hour run at 70% VO_{2max}; and a run to exhaustion at 80% $\dot{V}O_{2max}$. During SCM, the subjects consumed one of four different meals: three CSD (Ergo, Go Sports, and Gatorlode), and the LMCR. In addition, one SCM was conducted with half-rations. Oxygen consumption, heart rate, and rating of perceived exertion were evaluated during each phase of the SCM. Time in minutes (mean $\pm$ SD) to exhaustion at 80% $\dot{V}O_{2max}$ for Ergo (42.3 $\pm$ 8.9), Go Sports (39.4 $\pm$ 13.3), and Gatorlode (37.7 $\pm$ 8.6) was not significantly different from that for LMCR (36.4 $\pm$ 13.0) but was greater than that for half-LMCR (30.3 $\pm$ 9.3). O_2 consumption, heart rate, and rating of perceived exertion were not affected by meal type but did increase over time for each stage of the SCM. We conclude that the amount of calories ingested was responsible for the differences noted in time to exhaustion. We further conclude that the CSD represent a readily available source of energy and fluid that could be used to replace and/or supplement the current LMCR.

Introduction

The use of commercial sport drinks (CSD) is quite popular in the sporting community They are consumed to enhance performance, which they do by providing fluid and electrolyte replacement as well as adding extra energy during the activity.[1] Their acceptability and effectiveness as a supplement in military field rations for providing rehydration and energy have also been evaluated.[2-5] However, whether CSD could replace a particular ration used in the military is not known.

At present, the Canadian military uses both individual meal packages and light meal combat rations (LMCR) to meet the energy requirements of personnel in the field. The former are used during routine military activities of a sustained nature, whereas the latter are used during quick-strike activities, such as combat maneuvers that may last up to 48 hours and require intensity levels of greater than 60% of maximum oxygen uptake ($\dot{V}O_{2max}$). It is during the latter type of activity that CSD, with their high proportion of carbohydrate (CHO) and added electrolytes, could be more advantageous than the LMCR, because the metabolism of CHO becomes more important than that of fat[6-8] at higher exercise intensities, and the replacement of fluid and electrolytes is essential for sustained activity.

The importance of CHO as a substrate for contracting skeletal muscle has been recognized. Numerous studies[9-14] have demonstrated the critical role of muscle glycogen as a determinant of endurance exercise performance and the benefit of increasing dietary CHO intake before exercise. In addition, other studies have revealed the importance of restoring muscle glycogen after intense exercise and before subsequent activity as critical for maintaining performance levels.[15-17] There are a number of factors that influence the rate of muscle glycogen resynthesis, most notably the type and amount of CHO ingested and the timing of the CHO ingestion before, during, and after exercise.[11,18,19]

CSD have been designed to deliver and make energy more readily available to the skeletal muscle for use during strenuous physical activity This is done by adjusting the CHO composition of the drink to promote fast emptying from the stomach, adjusting the type of CHO to enhance uptake into the muscle, adding specific electrolytes to replace those lost in the sweat, and adjusting the amount of energy of the CSD to ensure that the majority comes from CHO, because fat and protein take longer to digest. It was hypothesized that the CSD would increase time to exhaustion compared with the LMCR, because the CSD may enable faster delivery of energy to the active muscle. The purpose of this study was to compare time to exhaustion and cardiovascular responses during a simulated combat maneuver (SCM) after ingesting either CSD or LMCR.

Methods

Subjects

Three civilian and six military personnel (eight males and one female) with mean $\pm$ SD values for age of 33 $\pm$ 6 years, height of 1.79 $\pm$ 4 5 m, and weight of 79.1 $\pm$ 11 kg participated in this study. All subjects were regularly active in aerobic activities and had a treadmill $\dot{V}O_{2max}$ of 51 $\pm$ 5 mL/kg/min. For the Canadian Forces, this level of aerobic fitness would put them in the excellent category for their age. The subjects were fully informed of the details, discomforts, and risks associated with the experimental protocol, and written informed consent was obtained. The subjects were asked to refrain from heavy exercise and alcohol use for 24 hours before each trial and to refrain from caffeine or products containing caffeine for 12 hours before each session.

Procedures

The subjects visited the laboratory on seven occasions During the initial visit, subjects were medically screened and had their VO_{2max} determined on a motor-driven treadmill This evaluation began at a treadmill speed of 5.5 mph and increased 1 mph every 4 minutes until a speed of 8.5 mph was obtained. Thereafter, the grade of the treadmill was increased 1% per minute until each subject was exhausted. Oxygen consumption (VO_2) was recorded and heart rate (HR) was monitored every minute. The peak VO_2 measured was defined as the $\dot{V}O_{2max}$. A VO_{2max} speed regression equation was also generated for each

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subject from this trial and was used later to derive the speeds of the treadmill that represented 50, 70, and 80% of the individual's $\dot{V}O_{2max}$

During the next six visits, which were scheduled every other week, one of the trials involved familiarization with the SCM procedures and the other five consisted of treatment trials of SCM. The SCM consisted of three activities: a 2-hour march at 50% of maximal aerobic capacity ($\dot{V}O_{2max}$) (simulating the march-in phase); a subsequent 1-hour run at 70% $\dot{V}O_{2max}$ (simulating the attack phase); and a final run to exhaustion at 80% VO_{2max} (simulating a fast-retreat phase that may occur during a combat exercise). During SCM treatment trials, the subjects consumed one of four different meals: three CSD (Ergo, Go Sports, and Gatorlode) and the LMCR, all of equal caloric content (approximately 1,500 kcal or 6,200 kJ). In addition, one more SCM was conducted with half-rations (750 kcal or 3,100 kJ). A time line of a treatment trial is shown in Figure 1 and explained below

The subjects arrived at the laboratory at 7 a.m. after an overnight fast. A catheter was inserted into an antecubital vein, and a 5-mL baseline sample was drawn. After this, blood samples were drawn immediately before and after every phase of exercise in the SCM To keep track of the individual's sweat loss, body weight was also measured before and after each exercise phase of the SCM. Food was delivered in three portions. The first portion contained 750 kcal or approximately 3,100 kJ and was given soon after the first blood sample and 2 hours before the march phase of the SCM.

The second portion contained 500 kcal or approximately 2,100 kJ and was delivered immediately after the blood sample, and weight was obtained at the end of the march and approximately 1.5 hour before the 70% $\dot{V}O_{2max}$ run phase of the SCM. The final portion contained 250 kcal or approximately 1,045 kJ and was delivered immediately after the blood sample, and weight was obtained after the 70% VO_{2max} run and approximately 1 hour before the final 80% VO_{2max} run to exhaustion.

During the half-ration trial, only the first portion of food was delivered. For the other two portions, the subjects were given a 500-mL flavored drink containing 2 kcal. All treatments were carried out in a blinded fashion, but subjects obviously knew when they received the CSD vs. the LMCR. However, the subjects were not aware of and could not identify the order of the CSD. The order of all of the treatments was randomized among the subjects

The subjects performed the SCM dressed in running shoes, shorts, and a T-shirt. The SCM were conducted on a treadmill in a climatic suite in which the temperature of the room was controlled at 13°C and relative humidity was maintained at 30%. After each phase of the SCM, the subjects left the chamber and rested in a waiting area, where the room temperature was maintained at 22 to 24°C.

To maintain hydration and to offset the expected fluid loss with exercise, during the first two phases of the SCM, water was given to the subjects at time 0 and every 30 minutes during these stages. The males consumed 300 mL and the female consumed 200 mL. No water was given during the final 80% VO_{2max} exhaustion phase.

During each exercise phase of the SCM, respiratory metabolic parameters and rating of perceived exertion (RPE)[20] were measured at the same time. For the march (50% VO_{2max}) phase, these were measured at 10, 40, 70, and 100 minutes For the 70% $\dot{V}O_{2max}$ run phase they were measured at 10, 30, and 45 minutes. For the 80% $\dot{V}O_{2max}$ phase, they were measured at 10 and 30 minutes and every 15 minutes thereafter

HR was measured every 10 minutes during each of the exercise phases of the SCM.

The composition and macronutrient, mineral, energy, and fluid contents of the various products are listed in Table I. The analyses for the LMCR were provided by the Directorate of Food Services of the Canadian Department of National Defense. The composition of the other products was taken from the labeling on the packaging.

Measurements

During the treadmill runs, VO_2, carbon dioxide production, and expired ventilation were measured with an automated metabolic cart system (OCM-2, AMETEK, Pittsburgh, Pennsylvania). HR during the VO_{2max} runs and the SCM trials was monitored continuously (Vantage XL Polar System, Port Washington, New York). For the treatment trials, plasma from the pre-exercise venous blood samples was assayed for caffeine concentration by gas chromatography-mass spectrometry electron impact single-ion monitoring (model MSD 5970a, Hewlett Packard, Palo Alto, California) This was done to ensure that subjects adhered to the protocol to refrain from caffeine ingestion, for it is known that caffeine can affect performance [21]

Another aliquot of each blood sample was immediately deproteinized and subsequently assayed for glucose (GOD-PAP, Boehringer Mannheim, Mannheim, Germany) and lactate.[22] Insulin lev-

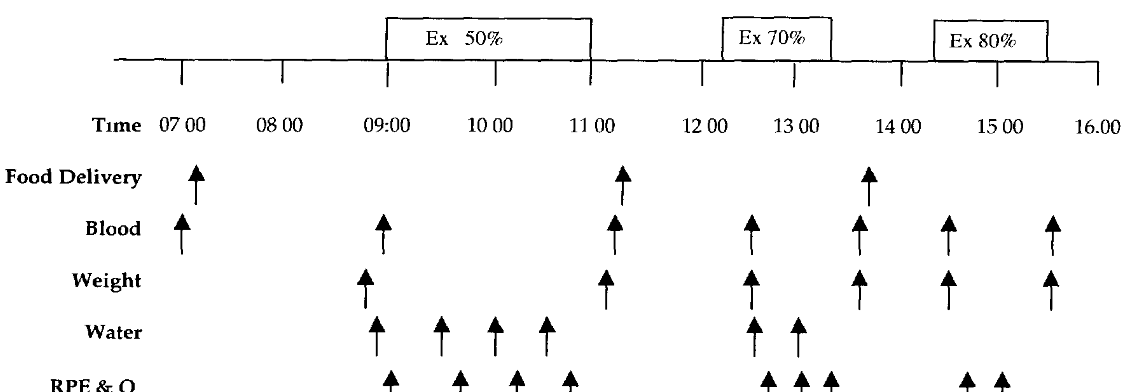

Fig 1 Time line for blood sampling, weighing of subject, delivery of food and water, measurement of RPE, and oxygen consumption during a SCM

TABLE I

COMPOSITION, MACRONUTRIENTS, MINERALS, AND ENERGY CONTENT OF THE PRODUCTS

	LMCR	Go Sports	Ergo	Gatorlode
Distributor	Canadian Forces	Systems Go International	U.S. Army	Gatorade Company
Composition	Pepperoni sticks (50 g) Rice Krispie square (37 g) Raisins (40 g) Hot chocolate (28 g) Fruit beverage powder × 2 (22.7 g)	Milk protein Low-fat milk Maltodextrin Sucrose Vitamin blend	Fructose Glucose Maltodextrin	Dextrose Maltodextrin Vitamin blend
Macronutrients per Package or Serving (g)				
Carbohydrate	238	43	43	49
Fat	45.1	3	0	0
Protein	28.7	14	0	0
Minerals per Package or Serving (mg)				
Potassium	1,424	390		
Sodium	1,461	250	20	60
Phosphorus	550			
Calcium	375			
Magnesium	120			
Iron	7.5			
Energy Content per Packet or Serving	1,500 kcal or 6,250 kJ	260 kcal or 1,090 kJ	170 kcal or 710 kJ	200 kcal or 840 kJ
Number of servings used	1	5.75	8.8	7.5
Amount of water per serving	624 mL or 22 oz	230 mL or 8 oz	340 mL or 12 oz	230 mL or 8 oz

els were measured by radioimmunoassay (Insulin RIA 100, Pharmacia and Upjohn, Uppsala, Sweden). Hydration status using plasma osmolality was measured using the Advanced Micro-Osmometer model 3300 (Advanced Instruments, Norwood, Massachusetts). Sweat rates were calculated from changes in nude weight corrected for respiratory[23] and metabolic weight loss[24] to account for water lost through respiration and the difference in molecular weight between oxygen and carbon dioxide, respectively.

Statistics

One-way repeated-measures analysis of variance (ANOVA) was used to compare the times to exhaustion during the 80% $\dot{V}O_{2max}$ run across treatment trials. For all other variables, two-way repeated-measures ANOVA was used to compare the dependent variables across treatments and time.[25] When the ANOVA yielded a statistically significant *F* ratio, then a post hoc comparison of means was done using a means comparison contrast technique.[25] Huyn-Feldt epsilon factors were used to adjust degrees of freedom for multiple comparisons. Statistical significance was accepted at the $p \leq 0.05$ level.

Results

A residual amount of caffeine was detectable in the plasma before the commencement of all trials and ranged from 2.8 to 6.1 μM. Osmolality values were normal for plasma separated in EDTA tubes and ranged between 300 and 305 mOsm/kg H_2O, implying that the pretrial hydration status of the subjects was consistent across trials.

For the initial 2-hour march at 50% VO_{2max}, the type of meal did not affect VO_2 (range, 2.05–2.13 L/min), HR (range, 119–121 beats/min), or RPE (range, 9.3–10.1), but it did affect the respiratory quotient (RQ). The RQ for Ergo (0.96 ± 0.04) and Gatorlode (0.96 ± 0.05) was significantly higher than that for LMCR (0.93 ± 0.05) and half-LMCR (0.93 ± 0.05). RQ with Go Sports (0.94 ± 0.04) was similar to all others.

For the 1-hour 70% $\dot{V}O_{2max}$ session, the type of meal again did not affect VO_2 (range, 2.7–2.8 L/min), HR (range, 142–146 beats/min), or RPE (range, 16.1–16.6). However, RQ (mean ± SD) was significantly higher for Ergo (0.97 ± 0.04) and Gatorlode (0.95 ± 0.04) compared with Go Sports (0.93 ± 0.04), LMCR (0.92 ± 0.4), and half-LMCR (0.87 ± 0.04). The results for half-LMCR were also significantly lower than those for Go Sports and LMCR during this phase.

After 10 minutes of exercise at 80% $\dot{V}O_{2max}$, $\dot{V}O_2$ (range, 3.12–3.24 L/min), HR (range, 158–163 beats/min), and RPE (range, 13.5–14.0) were similar for all meal types. RQ again varied. RQ for the LMCR (0. 95 ± 0.03) and half-LMCR (0.93 ± 0.03) was similar and significantly lower than that for the CSD: Ergo (1.00 ± 0.04), Gatorlode (0.99 ± 0.02), and Go Sports (0.99 ± 0.03). At exhaustion, $\dot{V}O_2$, HR, RPE were again similar, and although RQ tended to be lower for the ration meals, it was not significantly different from that for the CSD (Table II).

Times to exhaustion during the 80% VO_{2max} run for Ergo, Go Sports, and Gatorlode were similar to those for the full LMCR but were significantly longer than those for the half-LMCR (Table II).

The type of meal consumed did not affect sweat rate (mean ± SD, kg/h), but, as expected, sweat rates increased significantly as exercise intensity increased: 0.439 ± 0.188 at 50% VO_{2max}, 0.755 ± 0.328 at 70% VO_{2max}, and 1.073 ± 0.539 at 80% VO_{2max}. The total amount of fluid loss was also similar for all food trials.

Figure 2 shows the lactate response before and after each phase of the SCM and for each meal type. Generally, lactate values showed little if any change before and after exercise except for the higher values observed after the run to exhaustion at 80% $\dot{V}O_{2max}$. In addition, after this run to exhaustion, lactate values were significantly higher for the half-LMCR trial compared with Go Sports.

TABLE II

PHYSIOLOGICAL AND PERFORMANCE VARIABLES AT EXHAUSTION FOR THE 80% VO_{2MAX} PHASE

Parameter	Ergo	Go Sports	Gatorlode	LMCR	Half-LMCR
Time (min)	42.3 ± 8.9	39.4 ± 13.3	37.7 ± 8.6	36.4 ± 13.0	30.3 ± 9.3[a]
VO_2 (L/min)	3.35 ± 0.56	3.21 ± 0.49	3.28 ± 0.70	3.41 ± 0.73	3.31 ± 0.53
RQ	0.97 ± 0.04	0.96 ± 0.04	0.96 ± 0.03	0.94 ± 0.04	0.93 ± 0.04
RPE	16.4 ± 1.9	16.5 ± 2.3	16.3 ± 2.8	16.1 ± 2.7	16.2 ± 2.7
HR (beats/min)	167 ± 15	171 ± 15	166 ± 16	171 ± 11	170 ± 15

Values are means ± SD

[a]Half-ration were significantly different from the Ergo, Go Sports, and Gatorlode commercial supplements in terms of time to exhaustion only. All other variables were not significantly different.

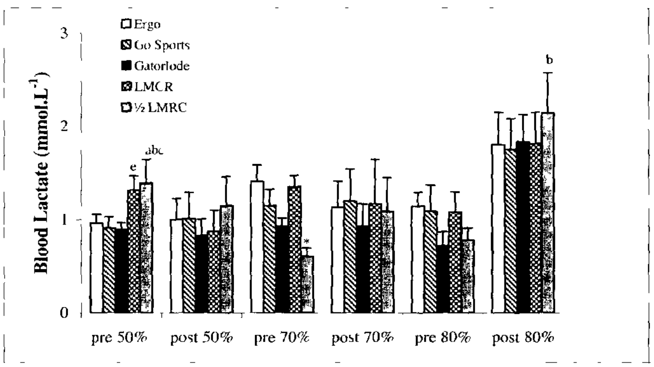

Fig. 2. Blood lactate (mean ± SEM) before and after each exercise session for the combat maneuver. *Half-LMCR was significantly different from all other meals. [a]Ergo was significantly different from half-LMCR. [b]Go Sports was significantly different from half-LMCR. [c]Gatorlode was significantly different from half- LMCR. [e]Gatorlode was significantly different from LMCR.

Figure 3 shows the glucose response before and after each phase of the SCM and for each meal type. Before beginning the exercise at 70% VO_{2max}, glucose was increased significantly for Gatorlode compared with half-LMCR and Go Sports. Furthermore, before the run to exhaustion at 80% $\dot{V}O_{2max}$, glucose was significantly lower for half-LMCR compared with the other meals. However, before and after exercise at 50% $\dot{V}O_{2max}$ and after the other exercise sessions, blood glucose was similar among all trials.

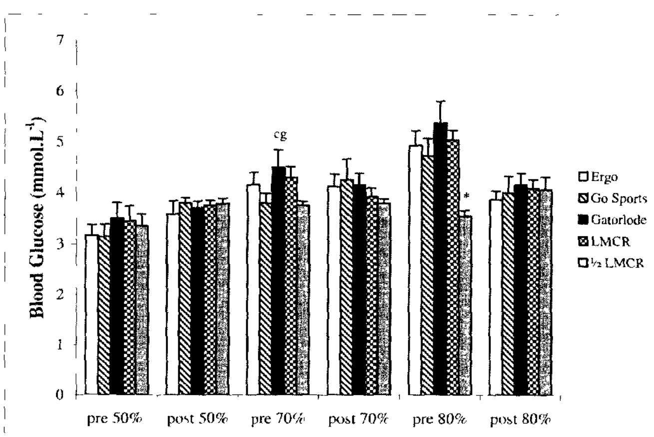

Fig. 3. Blood glucose (mean ± SEM) before and after each exercise session for the SCM. *Half-LMCR was significantly different from all other meals. [c]Gatorlode was significantly different from half-LMCR. [g]Gatorlode was significantly different from Go Sports.

After the run to exhaustion, blood glucose values also were reduced significantly compared with pre-exercise levels.

Figure 4 shows the insulin response before and after each phase of the SCM for each meal type. In response to feeding and the CSD, insulin levels were increased before initiating the three exercise bouts throughout the SCM. In addition, before beginning the first exercise session at 50% $\dot{V}O_{2max}$, insulin levels were significantly greater in the 100% CHO meals (i.e., Ergo and Gatorlode) compared with the other meals. Furthermore, before the exercise at 70% VO_{2max}, insulin values were increased significantly with Ergo compared with LMCR. Insulin values were also reduced significantly before exercise during the half-LMCR trial when no food was provided. After all of the exercise sessions, insulin values were reduced to similar levels among all of the trials.

Discussion

The findings from this study have shown that the use of CSD can substitute for the use of LMCR during SCM. Exercise performance was maintained but not improved significantly with the use of the drinks. However when the energy provided by the meal was reduced, as was the case during the half-ration trial, exercise performance was degraded. These findings imply that the amount of calories in the meal, and not the meal composition, affected run times to exhaustion. However, it is equally important to consider the impact of the macronutrient composition of the meals on performance.

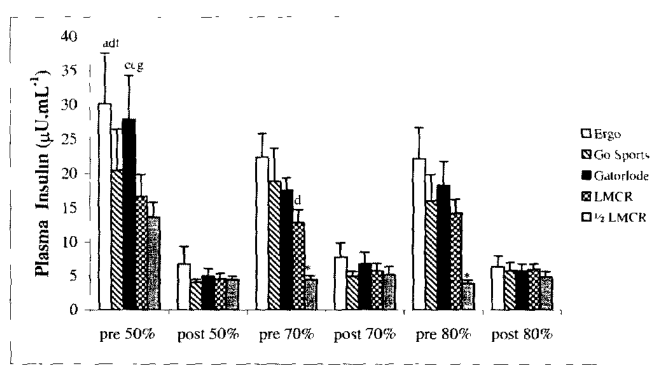

Fig. 4. Plasma insulin (mean ± SEM) before and after each exercise session for the SCM. *Half-LMCR was significantly different from all other meals. [a]Ergo was significantly different from half-LMCR. [c]Gatorlode was significantly different from half-LMCR. [d]Ergo was significantly different from LMCR. [e]Gatorlode was significantly different from LMCR. [f]Ergo was significantly different from Go Sports. [g]Gatorlode was significantly different from Go Sports.

Two of the meals provided energy exclusively in the form of CHO (i.e., Ergo and Gatorlode), whereas LMCR and Go Sports have different proportions of fat, protein, and CHO. The proportion of CHO in the latter two meals, however, was still high at 76 and 72%, respectively. Coyle[16] suggests that, whenever possible, the proportion of CHO in the food should be greater than 70% to promote optimal muscle glycogen resynthesis after exercise. All of the meals met this requirement. Furthermore, other studies[18,26–28] have shown that there is an upper limit for the rate of glycogen synthesis that can be met by ingesting 50 g of high-glycemic CHO every 2 hours. Ingesting more than this amount does not increase the rate of synthesis.

As shown in Table III, all of the meals delivered close to this amount of CHOs before each exercise session except for half-LMCR. LMCR and Go Sports provided less than 50 g before the run to exhaustion at 80% VO_{2max}, but this amount was consumed 1 hour rather than 2 hours before exercise. In addition, Coyle[16] suggests that the CHOs should be ingested as soon after exercise as possible to maximize resynthesis. The meals in this study were ingested within 15 minutes after cessation of exercise. From this discussion, it can be seen that the meals were more alike than dissimilar and that CHO was probably responsible for the majority of the energy delivered. Thus, the composition of the current LMCR is appropriate to maintain physical performance during sustained high-intensity exercise.

Although the RQ values were significantly higher throughout the trials for Ergo and Gatorlode, except at exhaustion, compared with LMCR, these differences were small. Nevertheless, the higher RQ values represent a higher proportion of CHO utilization for these CSD, which translated into significant improvements in performance compared with half-LMCR, which restricted caloric intake. There was even the trend for Ergo, which supplied all of its energy via CHO, to be better than the full LMCR.

This finding suggests the importance of having meals high in CHO content for performance maintenance and improvement during strenuous exercise and supports the works of others.[12,14] However, Gatorlode, which also provided all of its energy in the form of CHO, was associated with performance times very similar to those seen with LMCR despite higher RQs. This result suggests that other factors in addition to CHO availability influenced performance. As will be discussed later, Ergo was the only product that maintained a euhydrated state throughout the LMCR.

The degraded performance for the trial with half-rations compared with the CSD confirmed the findings of others[29–32] who showed that CHO ingestion during recovery from exercise maintains or improves performance in subsequent exercise. The lower blood glucose and insulin levels before the run to exhaustion for the half-LMCR trial attest to the importance of CHO supplementation on subsequent exercise performance.

TABLE III

AMOUNT OF CARBOHYDRATES IN GRAMS CONSUMED BEFORE EACH EXERCISE SESSION

Session	Ergo	Go Sports	Gatorlode	LMCR	Half-LMCR
50% VO_{2max}	186 0	121 5	180 2	119 0	119 0
70% VO_{2max}	124 0	81 1	120 1	79 2	0 0
80% VO_{2max}	62 0	40 5	60 1	39 6	0 0

However, the present results conflict with those of Casey et al.,[33] who did not find a significant increase in cycling performance to exhaustion at 70% VO_{2max} after initial exercise at 70% VO_{2max} was followed by ingestion of 76 g of CHO during a 4-hour period. Because the resynthesis of muscle glycogen was not affected by the ingestion of CHO, Casey et al.[33] suggested that a significant proportion of the ingested CHO was used to replenish liver glycogen. Liver glycogen was resynthesized during the 4 hours of recovery, and this, the authors believed, compromised the resynthesis of muscle glycogen. Thus in certain situations, the provision of CHO after an exercise bout may not lead to subsequent improvement in exercise performance.[33]

An important point of interest is the distance that the individuals covered during the run to exhaustion at 80% $\dot{V}O_{2max}$. These distances (in km, mean ± SD) were 8.8 ± 2.2, 8 2 ± 3.2, 7.8 ± 1.9, 7.6 ± 3.3, and 6.3 ± 2.2 for Ergo, Go Sports, Gatorlode, LMCR, and half-LMCR, respectively. Again, as in the time analysis, after ingestion of the CSD, distances covered were significantly greater than with the half-LMCR in spite of the fact that individuals at exhaustion perceived the effort as similar (Table II). In addition, after ingesting Ergo, individuals went more than 1 km farther than with the LMCR. This extra distance would put them well out of rifle range, suggesting that Ergo might be more advantageous than the LMCR. However, Ergo requires 3 L of water for consumption. Thus, in addition to their standard 1-L canteen, the soldiers would have to carry an additional 2 L of fluid

The question of the amount of water that should be carried in the combat situation poses an interesting dilemma Dehydration issues are important, and it is well known that fluid loss from activity, if not replaced, will have a negative effect on subsequent performance.[34,35] In fact, a mass loss of only 1.8% can impair exercise performance.[36] In the present study, we ensured that individuals were adequately hydrated before each phase of the combat maneuver. However, if only the water required for each of the meals was used for rehydration, there would have been 0 66, 2 95, 1.28, and 1.67 L of water ingested for the LMCR, Ergo, Go Sports, and Gatorlode trials, respectively

The amount of water loss during the exercises bouts was 2.28, 2.39, 2.34, and 2.31 L for the LMCR, Ergo, Go Sports, and Gatorlode trials, respectively Only the Ergo replaced the fluid lost. Furthermore, the amount of fluid given with LMCR is far from adequate and would result in a net loss of fluid from the body equivalent to 2% of the body mass if additional fluid was not provided after exercise. Thus, without fluid replacement, performance with the LMCR would have been compromised further

The maintenance of hydration status has a greater positive impact on performance than the detrimental effect of increased energy expenditure (15–25 kcal/h or 60–100 kJ/h) required to carry the additional weight of the fluid. Furthermore, the majority of this weight (2 kg) would be ingested during the maneuver and would be a benefit to the soldier. The CSD does not have to replace the LMCR, but the drinks could be an important supplement for providing both fluid and energy requirements. During and after heavy exercise, individuals are more likely to replenish energy by drinking fluids than by eating solids, and in the combat situation, soldiers consume whatever is easiest to carry, prepare, and ingest.

Generally, it is known that soldiers on exercises expend more energy than they take in and that they drink insufficient fluids to maintain hydration.[5,37] Montain et al.[3] found that soldiers consuming CSD or practicing good food discipline were more likely to sustain physical performance than those eating only a portion of their food. In addition, Montain et al.[3] stated that CSD would provide an accessible source of calories that could be advantageous when the availability of food is restricted or inadequate food consumption is likely. Also, Askew et al.[2] showed that soldiers who were given a CHO fluid supplement during exercise at altitude increased the distance covered during 4 days of running by 12.5% compared with the group that did not receive supplements. The implication of the current study is that hydration also would be better maintained with CSD.

In conclusion, this study has shown that the CSD and military LMCR were similarly effective for maintaining performance in a controlled environment. However, definite advantages could be realized if CSD were used as supplements to the rations in the real combat situation. These advantages would be in the form of better hydration and an additional energy supply that would be readily available and easily ingested. It must be remembered, however, that these results were obtained from a small sample (only 9 subjects) and may not represent the military population, although the majority of subjects were soldiers. Originally, 30 individuals were recruited and began the experiment; however, because of time constraints, transfers, injury (unrelated to the experiment), and not wanting to continue, 21 individuals did not complete the study.

Acknowledgments

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