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The Effect of Two Sports Drinks and Water on GI Complaints and Performance During an 18-km Run

Abstract

Gastrointestinal (GI) complaints are frequently experienced during running. Sports drinks to prevent dehydration and hypoglycemia during exercise are generally used. The aim was to investigate the effect of 3 different drinks on GI complaints and performance during competitive running in a controlled field study. Ninety-eight well-trained subjects (90 M, 8 F, age 41 ± 8 y) performed a competitive 18-km run three times within 8 days. The study was a controlled, standardized field experiment following a randomized, crossover design. Three different drinks were compared: water, a sports drink (CES), and a sports drink with added 150 mg/l caffeine (CAF). The incidence of GI complaints and the effect of the drinks on performance was studied. Each subject consumed 4 times 150 ml as follows: at the start, after 4.5 km, 9 km, and 13.5 km. Fluid intake was controlled. Incidence and intensity of GI complaints during the run were determined using a 10 points scale questionnaire. There were no significant differences in performance between the 3 drinks. Run time (18 km, mean ± SD): WAT 1 : 18 : 03 ± 08 : 30, CES 1 : 18 : 23 ± 08 : 47, CAF 1 : 18 : 03 ± 08 : 42. The use of carbohydrate-containing sports drinks led to higher incidences of all types of GI complaints compared to water. Significant differences ($p < 0.05$) were reached for flatulence; incidence: WAT 17.9 %, CES 28.6 %, CAF 30.6 %, and reflux; incidence: WAT 55.7 %, CES 78.6 %, CAF 72.5 %. There were no significant differences in intensity of the GI complaints. Addition of caffeine to CES had no effect on GI complaints, compared to CES alone. We conclude that sports drinks used during an 18-km run in cool environmental conditions do not support the performance better than mineral water. The use of sports drinks during an 18-km run leads to a higher incidence of both upper and lower GI complaints compared to water. Addition of caffeine to the sports drink has no effect on either running performance or GI complaints.

Key words
Exercise · sports drinks · performance · caffeine · carbohydrates

Introduction

Gastrointestinal (GI) disturbances are commonly experienced by people who exercise, during both training and competition. These disturbances may impair athletic performance. Runners specifically suffer from these complaints, which is probably related to the up and down bouncing movements, which may induce stress on the abdominal organs [14].

A variety of complaints may occur during exercise, which may be attributed to disorders of the upper (esophagus and stomach) and the lower (small bowel and the colon) GI tract. Upper GI complaints comprise reflux, nausea, bloating, and upper abdominal cramping. Lower GI complaints comprise lower abdominal cramping, the urge to defecate, increased frequency of bowel movements, flatulence, and diarrhoea. All these complaints suggest that exercise can influence GI function, and most

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of them seem to be related to alterations in GI motility. For the etiology of GI complaints during exercise, we refer to van Nieuwenhoven, 1999 [22].

A number of field studies in which participants of endurance events were surveyed on GI complaints have been reported in the last two decades [7,15,18,24,25]. It appeared that up to 42% of the participants suffer from one or more GI complaints during, or immediately after exercise. In general, lower GI complaints are more common than upper GI complaints, women experience more often complaints than men, younger athletes experience more often complaints than older athletes, exercising at a high intensity induces more complaints than exercising at a lower intensity, and running induces more complaints than cycling, swimming, or rowing [22].

Dietary intake is probably also involved in the etiology of exercise-induced GI complaints, although data are scarce. Rehrer et al. [16] correlated dietary intake (including food and fluid intake) with the prevalence of GI complaints during triathlon competition. It was observed that, in general, triathletes who consumed hypertonic carbohydrate solutions during exercise and those who consumed food products high in dietary fibre, fat, or protein before competition suffered more from GI complaints. Peters et al. [12] studied the prevalence of exercise-related GI complaints among long-distance runners, cyclists, and triathletes, and determined the relationship of different variables to GI complaints. They observed that exercise-related GI complaints were significantly related to the occurrence of GI complaints during nonexercise periods, age, gender, and years of training, and type of diet as well [12]. They also investigated the relationship between GI complaints and the type of consumed meal during exercise in a laboratory setting. Three different types of meals were studied; a semisolid carbohydrate meal, a liquid carbohydrate meal, and a water placebo. They reported that nausea lasted longer after ingestion of the water placebo, compared to a semisolid meal [13].

Exercise leads to sympathetic activation and alterations in plasma hormone concentrations. Consequently, splanchnic blood flow decreases to very low levels [17].

Continuing dehydration (> 3% bodyweight) leads to an increase of blood viscosity [19]. Exercise combined with dehydration may therefore reduce intestinal blood flow to a very low level, which is detrimental with respect to GI complaints. It has been demonstrated that dehydration, which is often accompanied with hyperthermia, leads to a slower gastric emptying which correlates with GI complaints during exercise [10,15,20].

Commercially available sports drinks to prevent dehydration and hypoglycemia during exercise are frequently used in daily practice. Laboratory studies have demonstrated that ingestion of these drinks improves hydration status, and performance lasting ≥ 1 hour [3,6]. One might expect that the use of these drinks also has a protective effect on the occurrence of GI complaints. In addition, some sports drink brands have recently added caffeine to their sports drinks since some laboratory experiments have demonstrated an enhancing effect of caffeine supplementation [2,4,8,9,11] on rowing, swimming, and cycling performance. Recently, we carried out a controlled laboratory study in which gastrointestinal function was measured in 10 athletes during 90 min of intense cycling. We compared three different drinks: water, a carbohydrate-electrolyte solution (CES), and a CES with added 150 mg/l caffeine. It appeared that there were no important differences in gastrointestinal function between the three drinks [21]. However, the effect of different types of drinks on GI function in a field setting with variable conditions has never been established. Hence, the aim of the present study was to investigate the effect of three different drinks on both GI complaints and performance in 98 well-trained subjects during 18-km competitive running in a randomized controlled crossover field study. We hypothesized that the use of a carbohydrate-containing drink leads to a shorter average running time and less GI complaints than water. In addition, we expected that addition of caffeine leads to increased performance.

Subjects and Methods

Subjects

Ninety-eight healthy subjects (90 males, 8 females) participated in the study. All subjects were well-trained (3 – 15 h running/week) competitive or recreational runners and triathletes. Their physical characteristics (mean ± SD) were: age, 41 ± 8 years; height, 1.78 ± 8 m; body weight, 72 ± 8 kg. Their self-reported habitual drink ingestion during running varied between 0 and 1000 ml/h. About 40% of the subjects usually consumed water during running, and about 60% usually consumed carbohydrate-containing beverages, mainly sports drinks. The subjects were fully informed about all procedures and risks of the study before their written informed consent was obtained. The study was approved by the Medical Ethical Committee of the University Hospital Maastricht.

Study design

The study was performed as a field test following a randomized crossover design. It consisted of a competitive 18-km run which each subject performed three times within 8 days (Saturday, Tuesday, Saturday). The run was performed on a traffic-free street circuit. In order to create a competitive element, we paid prize money for the 20 best male and 3 best female participants.

Test drinks

The intervention consisted of drinking four times 150 ml of noncarbonated mineral water (Spa®) (WAT), a carbohydrate-electrolyte solution (CES), or a CES containing 150 mg/l caffeine (CAF). The composition of these commercially available drinks is displayed in Table **1**. The CES and CAF drinks were similar in colour and taste and indistinguishable for the subjects. We did not choose a water placebo, since this is not used in sports practice.

Instructions to the subjects

The subjects were instructed to incorporate the run test into their usual training program, as a contest. They were asked to record food and fluid intake on the day of the first run and to follow the same intake protocol on the days of the following runs to minimize variation in output parameters. The subjects were also instructed about the items on the questionnaire, and how to fill it in.

Table **1** Composition of the test drinks

Content CES/l	*Content CAF/l*
	caffeine 150 mg
300 Kcal	300 Kcal
CHO (saccharose + maltodextrin) 68.8 g	CHO (saccharose + maltodextrin) 68.8 g
vitamins 106 mg	vitamins 106 mg
electrolytes 1190 mg	electrolytes 1190 mg
amino acids 210 mg	amino acids 210 mg
myoinositol 51 mg	myoinositol 51 mg
choline 100 mg	choline 100 mg
pH 3.95	pH 3.75

Testing procedures

The subjects always reported at the meeting point between 18 : 00 and 18 : 30 p.m. At 18 : 50, they were asked to get ready for the start and to consume 150 ml of one of the test drinks they were assigned to by means of a colour code. At 19 : 00 h the start shot was given. At 4.5 km, 9 km, and 13.5 km of the run, the subjects had to consume 150 ml of the same test drink. They were asked to stop and drink without spilling within 10 seconds. This was checked with accuracy by the research staff. After the run, the subjects were allowed to drink *ad libitum* of the test drink. The incidence and intensity of GI complaints during and immediately after the run were scored on a standardized questionnaire, which we also used in previous studies [13,17], on anchored 10 points scales (1 = not at all, 10 = very much). The items on which the subjects were asked to score are displayed in Table **2**. The questionnaires were completed after the subjects had showered.

Statistics

All data are presented as mean ± SD. Comparisons between the three drinks for the incidences of the different complaints, the intensities of the complaints which were reported, and the running times were carried out using a one-way ANOVA. In order to establish whether there were differences in incidence of complaints, the data were transformed in 1 (complaint present = score 2 or higher) and 0 (complaint not present = score 1) before analysis. We also performed a comparison of the running times of the 10 fastest (and therefore most competitive) athletes in the study using Friedman's nonparametric test. Statistics were performed using SPSS 8.0 statistical package for Windows.

Results

The climatical conditions during the three runs were comparable (≈ 21 °C). All subjects were able to complete the 3 runs without adverse events. The majority of the subjects reported 1 or more GI complaints during the runs (WAT: 78.5 %, CES: 89.8 %, CAF 88.8 %).

The incidence of the different complaints, the intensity of the complaints, which were reported, and the running times are displayed in Table **2**. The data demonstrate that the use of carbohy-

Table **2** Running performance, incidence and intensity of gastrointestinal and general complaints

Complaint	*WAT incidence (%)*	*CES incidence (%)*	*CAF incidence (%)*	*WAT score*	*CES score*	*CAF score*
Upper GI complaints						
– *reflux*	55.7	78.6*	72.5*	3.4	4.1	3.7
– *heartburn*	7.4	16.3	12.2	2.0	3.9	2.8
– *bloating*	34.7	34.7	42.9	4.6	4.2	3.6
– *upper abdominal cramp*	16.8	19.4	20.4	3.4	3.7	3.1
– *vomiting*	2.1	6.1	3.1	3.0	3.0	5.0
– *nausea*	5.2	11.2	6.2	2.8	3.3	3.0
Lower GI complaints						
– *intestinal cramp*	6.3	12.2	13.3	4.8	3.5	3.7
– *flatulence*	17.9	28.6*	30.6*	3.9	2.8	3.0
– *urge to defecate*	12.6	17.3	13.3	5.3	3.3	5.5
– *left abdominal pain*	8.4	18.4	13.3	4.1	3.7	2.5
– *right abdominal pain*	15.8	20.4	23.5	3.7	4.9	3.4
General complaints						
– *dizziness*	6.3	3.1	2.0	2.8	4.0	2.7
– *headache*	3.2	2.0	3.1	4.7	3.0	3.0
– *muscle cramp*	17.9	18.4	18.4	4.9	5.2	4.3
– *urge to urinate/urinate*	15.8	18.4	20.4	4.1	4.9	5.2
Runtime (mean h : min : s ± SD)	1 : 18 : 03 ± 08 : 30	1 : 18 : 23 ± 08 : 47	1 : 18 : 03 ± 08 : 42			

Incidence is percentage of participants who reported presence of the complaint, "score" = intensity score of the complaint, ranging from 0 – 10. n = 98, * = significant CAF and CES vs. WAT drate-containing sports drinks led to higher incidences of all types of gastrointestinal complaints compared to water, whereas the intensities of the complaints were similar (no significant differences). Significant differences were reached for the incidence of reflux ($p = 0.0001$, upper GI complaint) and flatulence ($p = 0.0236$, lower GI complaint). Supplementation of a CES with caffeine did not affect the incidence of GI complaints. No significant differences could be observed for the general complaints. In addition, consumption of a commercially available CES during an 18-km run did not lead to a better performance compared to water. The ANOVA resulted in a p-value of 0.981. Supplementation of a CES with caffeine had no effect on running performance. We also performed an analysis of the running time in a subgroup of the 10 fastest, and hence, the best trained and most competitive athletes. No significant differences in running time between the three test drinks could be observed (WAT: 1 : 03 : 50, CES: 1 : 03 : 54, CAF: 1 : 03 : 41). Friedman's analysis resulted in a p-value of 0.972.

Discussion

Commercially available sports drinks are used by a large and heterogeneous population of athletes, with a variable fitness level. It is therefore relevant to study these drinks in such a population. The data demonstrate that the use of carbohydrate-containing sports drinks led to a higher incidence of all types of gastrointestinal complaints compared to water. We used questionnaires to score the presence of a complaint. In order to discriminate between mild and severe symptoms, we also present the mean intensity score of each positive symptom. Significant differences in incidence were observed for reflux (upper GI complaint) and flatulence (lower GI complaint), while the intensity scores were not significantly different. In addition, the data show that consumption of a commercially available sports drink during an 18-km run did not lead to a better performance in a field setting compared to water. Supplementation of a sports drink with caffeine had no effect on this performance. This was the case in the whole group of 98 subjects, and also in a subgroup of the 10 fastest athletes, who were probably running close to their maximal capacities. This leads to reliable performance data, and an ergogenic effect of caffeine may be expected in this subgroup.

This study clearly shows that results obtained in laboratory experiments, usually in a limited number of subjects, cannot always be extrapolated to field conditions with a higher number of subjects. Field studies which were carried out in the past, surveyed nutritional intake after an endurance event. Subsequently, the investigators attempted to correlate this nutritional intake with the GI complaints, which were reported by the athletes. These types of study design make it difficult to establish which type of nutrition induces more or less GI complaints, since every athlete has his/her own specific nutritional habits. Moreover, it is almost impossible for the investigator to control food and drink intake during an endurance event. For these reasons we carried out a standardized field study with a crossover design of three 18-km runs. We decided to standardize the meals individually, since overall standardization of nutrition means that a number of subjects have to eat food that they normally do not eat during competition days, which could also influence the outcome of the study. Using a crossover design we also controlled for treatment order effects, environmental differences between the test days, for learning effects, and for possible effects due to fatigue, although the test days were 4 days apart. Hence, the only difference between the three test days were the drinks that were provided during the run. Such a field study design mimics a real endurance event much better than a laboratory situation. However, in this design the participants were forced to drink fixed amount of drinks, where in a normal field situation an athlete will drink *ad libitum*.

Using this design we were able to investigate the effect of a commercially available sports drink, a commercially available sports drink supplemented with caffeine, and mineral water on the prevalence of GI complaints and on performance. Although we know from previous studies carried out in our laboratory, that sports drinks, with or without caffeine, do not affect GI parameters [21] but do increase performance [6, 8] it appears that these data cannot be extrapolated to a field situation.

The question arises what causes the difference between the results obtained in a laboratory setting and a field study. One difference is the fact that in a laboratory setting the exercise intensity is usually standardized and constant, while in a field setting the intensity during the exercise is varying. Another factor is that in most laboratory studies cycle ergometers are used, while in the present study the exercise consisted of running. It is known that running is more associated with the occurrence of GI complaints than cycling [22]. Moreover, a field setting with a competition element and tactics induces mental stress and thus it is likely that this is not the case in a laboratory setting. Mental stress may have a negative influence on the occurrence of GI complaints [5] which outstrips a possible performance-enhancing effect of carbohydrate and caffeine.

Another question is why a carbohydrate-containing drink induces more mild upper and lower GI complaints than plain water. Sports drinks are designed to empty rapidly from the stomach. For this reason they usually contain approximately 7% carbohydrate or less, since a higher amount of carbohydrate slows the gastric emptying rate, and less fluid will become available for the body [1]. On the other hand, the amount of carbohydrate should be sufficient to postpone fatigue due to muscle and liver glycogen depletion combined with a low blood glucose concentration. It is known that the bowel is able to absorb 0.6 – 1.0 g exogenous carbohydrate/min, which can be oxidized during endurance type activities [23]. For these reasons the composition of a sports drink is based on a combination of sufficient carbohydrate supply and optimal rehydration. However, it may be possible that in the field, at least during running, this composition is not optimal with respect to the increased prevalence of GI complaints. A beneficial effect of carbohydrates on performance may be outstripped by GI complaints. Running induces more GI complaints than cycling. Apart from the mechanical stress due to the up and down movements of the abdominal organs during running, it may be possible that, if the athletes perform at their maximal capacities, running leads to a larger decrease in intestinal blood flow than cycling, leading to malabsorption of the ingested carbohydrates. This could lead to osmotic differences leading to intestinal water secretion instead of water absorption.

In the present study, supplementation of a sports drink with caffeine did not enhance performance, but had no detrimental effect on the prevalence of GI complaints. In our laboratory study, we were also not able to demonstrate important effects of caffeine on GI function during exercise [21]. It seems that supplementation of a sports drink with 150 mg/l is safe with respect to GI complaints. For exercise lasting longer than 1.5 h, one could expect a beneficial effect of carbohydrate-containing drinks to provide sufficient energy. It cannot be excluded that beneficial effects of caffeine supplementation occur during exercise lasting longer that 1.5 h. However, based on the present results we conclude that mineral water intake during 1 – 1.5 h running in moderate environmental conditions induces less GI complaints without limiting the exercise performance. Whether consumption of drinks that contain a lower amount of carbohydrate supports running performance while having no effect on GI complaints, remains to be studied.

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