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Gastrointestinal Complaints in Relation to Dietary Intake in Triathletes

Nancy J. Rehrer, Monique van Kemenade, Wineke Meester, Fred Brouns, and Wim H.M. Saris

This study examined the relationship between gastrointestinal (GI) symptoms and dietary intake in triathletes. Fifty-five male triathletes (age 31±6 yrs) were surveyed regarding the most recently completed half Iron Man triathlon. Questions were asked regarding GI symptoms and dietary intake. Fifty-two percent complained of eructation and 48% of flatulence. Other symptoms were abdominal bloating, vomiting urge, vomiting, nausea, stomachache, intestinal cramps, and diarrhea. More symptoms occurred while running than at other times. All individuals who had eaten within 30 min of the start vomited while swimming. Fat and protein intake was greater in those who vomited or had the urge to vomit than in those without these symptoms. Of the former, 93% had consumed a hypertonic beverage. Forty percent of those who drank a hypertonic beverage and only 11% of those who drank an iso- or hypotonic beverage had severe complaints. Four of five individuals with stomachache had consumed a strongly hypertonic beverage. All subjects with intestinal cramps had eaten fiber-rich foods in the prerace meal; only 10% of those without cramps had done so.

Gastrointestinal (GI) symptoms occur frequently in endurance athletes. Numerous surveys and case studies have shown that these symptoms occur regularly in long-distance runners. A 30–50% prevalence has been reported among marathon runners (7, 17, 21, 25). The most prominent symptoms reported include nausea, vomiting, stomachache, intestinal cramps, and diarrhea. In addition to these complaints are the less severe complaints of abdominal bloating, eructation, and flatulence. Although symptoms are commonly reported in runners, there is little information as to prevalence among participants of other endurance sports in which intensity and exercise time are similar. The paucity of reports of GI symptoms among bicyclists, cross-country skiers, speed skaters, and so forth

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may lead one to conclude that these symptoms are not as common in sports in which ground impact is absent or less severe.

The common practice of cyclists and skiers eating solid food immediately prior to and during competition, while runners often abstain, suggests that the type of movement plays a role in GI function during exercise and development of GI symptoms. Numerous other factors have been reported as possibly leading to GI symptoms during exercise: nutritional factors (2), stress factors (1), hydration status (11, 13), and changes in GI function as a result of these and other stimuli.

The present study was designed to evaluate the possible relationship between race-day nutritional intake in triathletes and the prevalence of GI complaints. Triathletes were chosen as subjects since both bicycling and running are included in competition, and because a wide variety of solid food as well as fluids are commonly ingested.

Materials and Methods

A retrospective telephone survey was conducted with triathletes who were contacted via triathlon clubs in The Netherlands and Belgium. Data were gathered concerning the most recently completed half Iron Man triathlon. Half-triathlon competition was chosen rather than full triathlon competition in order to increase the sample size and decrease the time lag between competition and the survey, since typically more half-triathlons are completed in a year. A half-triathlon includes 1.9 km swimming, followed by 90 km bicycling, and then 21.1 km running.

Prospective subjects were telephoned to determine whether they would be willing to participate. If they agreed, they were sent written information pertaining to the interview and then were telephoned again and interviewed. In this way the subjects had time to reflect upon the answers to the questions in preparation for the interview. This oral survey method also gave us a chance to probe further when clarification of answers was needed. The questionnaire included questions about the quantity and composition of fluids and solids consumed on race day, prior to and during competition. A list of GI symptoms was included and, if any had occurred, the time of occurrence was noted. In addition, the finishing time of the race in question, the best half-triathlon time, and data regarding training status and personal statistics (age, height, and weight) were collected.

Data were only collected from males and no selection was made as to age. The amounts of food and beverage consumed were asked in household measures. The nutritional composition of dietary intake was calculated through the Dutch Nutritional (NEVO) Tables (6), a computer program designed to calculate amounts of macro- and micronutrients in foodstuffs, and through information from producers of particular products. Percent energy, carbohydrate, fat, and protein, in addition to total amounts of solid food in grams and liquids in milliliters, were calculated per predetermined periods.

The race day was originally divided up into 10 periods for calculating intakes: (1) breakfast, (2) after breakfast until 30 min prior to the start, (3) the last half-hour before the start, (4) while swimming, (5) between swimming and bicycling, (6) bicycling (first half), (7) bicycling (second half), (8) between bicycling and running, (9) while running, and (10) immediately following the

race (within 15 min after the finish). In the final calculations, Periods 5 and 6 and Periods 8 and 9 were combined because very little was consumed between swimming and bicycling and between bicycling and running. Results are reported only for time periods during which significant differences were observed. In several tables, intakes are reported for further combined time periods for practical purposes. Unintentional water intake during swimming was noted since ingested pollutants or other components of the swimming water may result in GI disturbance.

All types of beverages consumed prior to and during competition were obtained and were made up in the laboratory according to how subjects said they had prepared them. Osmolality of the beverages was measured using the freezing-point method (Osmomat 030, Gonotec, Berlin). Carbohydrate content of the various beverages as consumed was determined using manufacturers' specifications, with correction made for dilution deviations.

Statistics included the chi square goodness-of-fit test and the Mann-Whitney test for small, non-normally distributed sample populations (e.g., when comparing intake for those with and without particular complaints) with a confidence interval of 95%. All GI complaints were noted. A distinction was made between severe and nonsevere symptoms. Severe complaints included nausea, vomiting urge, vomiting, stomachache, intestinal cramps, and diarrhea because these are symptoms that commonly impair performance and may bring with them health risks. Nonsevere complaints included eructation, flatulence, urge to defecate, and abnormal pressure (bloating) in the abdominal region. Difference in timing of meals was evaluated in relation to the occurrence of GI problems.

Results

Subjects

Fifty-seven subjects participated in the survey, and 55 were included in the data set. The other two were excluded, one because of his training status (more than two standard deviations less time spent training than the mean) and one because of insufficient data. The length of time the subjects had participated in endurance sport was 4.9±2.4 years (mean ± *SD*). Subjects had been training for the triathlon for 2.8±1.2 years, had participated in 3.9±2.6 triathlons, and had a best time of 5 hrs, 06 min±24.8 min. The most recent triathlon had been conducted in most cases 6 to 7 months prior to the survey, in a time of 5 hrs, 07 min±28.6 min. Mean age, weight, and hours spent training for the total group and for those with and without GI symptoms are given in Table 1. No significant differences were observed in the prevalence of GI symptoms relative to subject characteristics or hours spent training. Similarly, when those with severe GI symptoms were set apart, no differences were observed.

Forty-nine percent of the triathletes surveyed had GI symptoms, and 29% had one or more severe symptoms. Complaints were most common during running and least common during swimming (Table 2). The prevalence of specific severe complaints is displayed in Figure 1. Table 3 lists severe and nonsevere complaints during each phase of competition. The most common complaints were the less disturbing symptoms of eructation and flatulence. These two complaints were often accompanied by one or more severe complaints. Further

Table 1

Mean Age, Height, Weight, and Average Training Time Per Week

	Total group		With GI symptoms		Without GI symptoms[1]	
	Mean	*SD*	Mean	*SD*	Mean	*SD*
	N=57		*N*=27		*N*=30	
Age (yrs)	31	6	30	5	31	6
Height (cm)	179	13	181	7	180	6
Weight (kg)	74	7	72	7	75	7
Swimming (h)	3.4	1.4	3.2	1.1	3.6	1.6
Bicycling (h)	8.3	2.8	8.3	2.7	8.4	3.0
Running (h)	5.0	1.8	4.4	1.3	5.6	2.0

[1]No significant differences were observed between groups.

Table 2

Prevalence of GI Complaints Among All Triathletes Surveyed (*N*=55)

	N	%
GI complaint	27	49
Severe GI complaint[1]	16	29
Swimming	3	5
Bicycling	5	9
Running	11	20

[1]Including individuals who had one or more than one symptom.

results regarding the correlation of GI symptoms with intake is henceforth limited to those complaints listed as severe.

Beverage and Solid Food Consumption. A wide variety of beverages and foodstuffs was ingested on race day. A list of beverages and their CHO concentrations and osmolalities, as prepared by the athletes, is presented in Table 4. The variety in solid foods was larger still. A list of foods ingested before, during, and after competition is presented in Table 5. During the race itself (excluding pre- and postcompetition ingestion) mean carbohydrate intake from both fluids and solids was 272 g (54 $g \cdot h^{-1}$), resulting in a mean energy intake from carbohydrate of 4.5 MJ (911 $kJ \cdot h^{-1}$).

Upper GI Tract Symptoms. In the last half-hour prior to the race, a greater amount of fat had been consumed by those with a vomiting urge (9 en%) than by those without this symptom (1 en%) ($p<.05$). A similar trend was observed in those who vomited (10 en%) versus those who did not (1 en%), ($p=.12$). There was also a trend for mean protein intake to be greater in individuals with an urge to vomit (11 en%) and those who vomited (14 en%) than in those without these

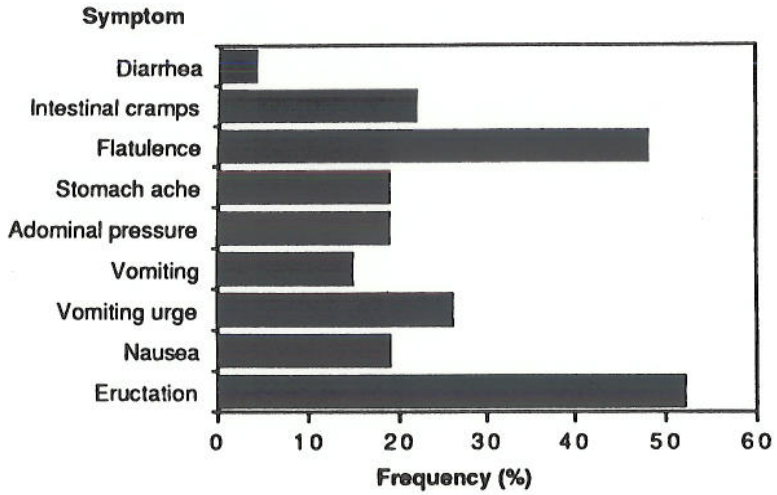

Figure 1 — Distribution of GI symptoms in triathletes with one or more symptoms (n=27).

Table 3

Specification of Symptoms at Specific Times During the Triathlon

	Severe complaint	N	Nonsevere complaint	N
Swimming	Nausea	1	Eructation	4
	Vomiting urge	3	Bloated	1
	Vomiting	2		
Bicycling	Nausea	2	Eructation	10
	Vomiting urge	1	Bloated	1
	Intestinal cramps	2	Flatuence	3
			Defecation urge	1
Running	Nausea	2	Eructation	6
	Vomiting urge	2	Bloated	2
	Stomachache	5	Flatulence	2
	Intestinal cramps	4		
Immediately after finish	Nausea	3	Eructation	1
	Vomiting urge	2	Bloated	2
	Vomiting	2	Flatulence	3
	Stomachache	2	Defecation urge	1
	Intestinal cramps	3		

Table 4

Osmolality and Carbohydrate Content of Beverages Consumed During the Half-Triathlon

Product	Osmolality (mOsm•kg^{-1})[1]	Carbohydrate[2]	
AA after activity drink (liquid)	306	74	(g/l)
AA high energy drink (liquid)	861	150	(g/l)
Champ (liquid)	1285	611	(g/l)
Coca Cola	680	110	(g/l)
Dextro-energie fruit drink (liquid)	1204	174	(g/l)
Dextro-energie orange drink (liquid)	927	142	(g/l)
Extran energie (liquid)	956	400	(g/l)
Extran energie (powder)	1260	600	(g+1l)
Extran thirstquencher (liquid)	268	40	(g/l)
Extran thirstquencher (powder)	261	42	(g+1l)
Isostar (liquid)	294	72	(g/l)
Isostar (powder)	308	75	(g+1l)
Orange juice	659	80	(g/l)
Perform (powder)	378	200	(g+1l)
Sport Energie (liquid)	414	75	(g+1l)
Sport Energie (powder)	301	90	(g+1l)
Sportline (liquid)	395	@70	(g/l)
Sugar water 8%	264	80	(g/l)
Sugar water 9%	285	90	(g/l)
Sugar water 10%	313	100	(g/l)

[1]Osmolality of beverages measured in lab of Dept. of Human Biology at U. of Maastricht as well as at Central Toxicology and Nutrition Institute, CIVO-TNO, in Zeist. [2]Carbohydrate content based on manufacturer's declaration and how product was prepared by athlete. Designation (g+1l) was used to denote g of carbohydrate *added to* 1 full liter.

symptoms (1 en%). A greater percentage of individuals who vomited or had the urge to vomit had consumed a hypertonic beverage (>325 mOsm·kg^{-1}) while bicycling (93%) than those without these symptoms (40%) (p<.05). Additionally, four of the five individuals with stomach cramps had also ingested a strongly hypertonic (>800 mOsm·kg^{-1}) beverage.

Solid food was more frequently consumed closer to the start of the race by individuals who vomited while swimming than those without this symptom. All athletes who vomited while swimming had eaten between breakfast and one-half hour before the start of the race, while only 27% of the athletes without this symptom had eaten in this time period. Similarly, all of the individuals who vomited had eaten in the last half-hour before the start, while only 14% of those without this complaint had eaten in this time period. A similar trend was seen in those with vomiting urge while swimming.

Lower GI Tract Symptoms. Fiber-rich foods (full-grain foodstuffs) had been consumed in the last meal before competition by all triathletes who experienced intestinal cramps immediately after the race. Only 10% of the

Table 5

Solid Foods Eaten Before, During, and After Triathlon Competition[1]

Before	During	After[3]
Banana	Banana	Banana
Bread	Muesli bar/energy bar	Sandwich
White	Bread roll	Meat
Raisin	White	Cheese
Whole-wheat, rye	Raisin	Yogurt
Spreads for bread	Sugar	Fruit
Apple-pear syrup	Cookies, graham-cracker type	Ice cream
Chocolate flakes	(Apple filled)	Bread roll
Jam	(Marzipan filled)	Raisin
Honey	(Pie apple, apricot)	(Glucose tablet)
Low fat margarine	(Fruit bar)	(Apple)
Cereal	(Kiwi)	(French fried potatoes)
Muesli	(Milkshake: lemon juice, banana, orange juice, water)	(Hamburger)
Cornflakes	(Chocolate candy bar)	
Finely milled, mixed grain-baby cereal	(Glucose tablet)	
Muesli bars		
Yogurt		
Cookies, graham-cracker type		
Rice pudding		
(Rice)[2]		
(Spaghetti)		
(Rice flour in water)		
(Macaroni with meat and sauted bell pepper and onions)		

[1]"Before" defined as breakfast and until the beginning of the race; "after" defined as within 15 min after finishing the race. [2]Items in parentheses eaten only by one individual. [3]The majority drank carbohydrate containing beverages immediately after the race but ate no solid food.

athletes without this complaint had eaten fiber-rich foods. Only one person had diarrhea, which he experienced immediately after the race. Interesting to note is that he had consumed 200 g more solid food than the mean (Table 6). Forty percent of the 55 surveyed triathletes defecated prior to competition. No correlation was found between defecation prior to the race and GI symptoms during competition.

GI Symptoms and Beverage Consumption. No relationship was observed between the amount of fluid consumed during the race and prevalence of any one symptom or GI symptoms in general (Table 7). A greater percentage of athletes who drank a hypertonic beverage (>325 mOsm·kg^{-1}) experienced GI disturbance (Table 8). There was a trend for individuals who drank a hypertonic beverage and experienced GI distress to have consumed a lesser total volume of fluids during the race (2,663±877) (mean±*SD*) than those who drank a hypertonic beverage but had no GI complaints (3,632±1,317).

Table 6

Solid Food Consumption During the Half-Triathlon In Relation to GI Symptoms (g)

Symptom	With symptom Mean	*SD*	Without symptom[1] Mean	*SD*
Nausea	325	224	500	237
Vomiting urge	395	219	500	242
Vomiting	240	268	500	232
Stomachache	395	215	495	242
Intestinal cramps	570	267	475	237
Diarrhea[2]	705	0	480	239

[1]No significant differences were observed between groups; [2]only one subject had diarrhea.

Table 7

Beverage Consumption During the Half-Triathlon In Relation to GI Symptoms (ml)

Symptom	With symptom Mean	*SD*	Without symptom[1] Mean	*SD*
Nausea	1940	846	2210	917
Vomiting urge	1740	438	2250	941
Vomiting	1540	463	2220	914
Stomachache	2380	1136	2160	892
Intestinal cramps	2340	1332	2160	858
Diarrhea[2]	2170	0	2180	915

[1]No significant differences were observed between groups; [2]only one subject had diarrhea.

Table 8

Prevalence of Severe GI Complaints and Osmolality of Beverage

	n	%
Hypotonic/isotonic (<325 mOsm/kg)	4/36	11
Hypertonic[1] (>325 mOsm/kg)	8/19	42

[1]A significant difference was observed in frequency between hypo-/isotonic and hypertonic ($p<.05$).

Discussion

The observed occurrence of severe gastrointestinal symptoms among triathletes during competition (49%), including the less severe symptoms of excessive eructation, flatulence, and abdominal bloating, concurs with earlier reports of GI disturbance: in triathletes, 24–55% for any one symptom (26) and 50% for one or more upper GI tract symptoms (28); in marathon runners, 6–38% for any given symptom (7) and 52% for one or more symptoms (17); and in ultra-marathon runners, 43% for one or more symptoms (14). Additionally, 83% and 81% of marathon runners (21) and "enduro" athletes (29), respectively, are reported as having experienced GI symptoms at one time or another during training.

The finding that severe complaints occurred more frequently during the running phase of competition than during either swimming or bicycling, supporting earlier results of Sullivan (26), is possibly related to the mechanical jarring which is twice as large during running versus bicycling (18). Sullivan questioned triathletes about the frequency of symptoms during both training and competition and found that 38% only had symptoms while running and that only 5% had similar symptoms in all three activities (26).

Results of the present study indicate that several components of the race-day diet may be related to GI symptoms. Increased amounts of protein, fat, and increased beverage osmolality, all factors that decrease gastric emptying, were correlated with an increased prevalence of GI symptoms. Results of several studies indicate that average emptying rates vary widely between individuals (12, 13). When gastric emptying rates in individuals who frequently experienced GI distress while running were compared with those who did not, no significant differences in mean gastric emptying rate of a carbohydrate containing beverage during exercise was observed (16). Apparently a slowed emptying rate, relative to one's norm, may be associated with problems of the upper GI tract. This may be related to effects of increased volume and pressure in the stomach, which may be further increased by gastric secretion.

A positive correlation has been observed between gastric secretion and gastric residue osmolality (24), and there is evidence that gastric secretion is increased with increasing beverage osmolality (5, 15). Thus, with strongly hypertonic beverages, the larger remaining gastric volume, due to a reduced gastric emptying rate, may be further increased by increased gastric secretion. Hypertonic solution presence in the intestine is known to increase intestinal secretion (10). If the residue is still hypertonic upon reaching the intestine, increased intestinal secretion would be expected. Supporting our findings are reports from Maughan et al. (9) of GI distress with strongly hypertonic beverage ingestion (1,915 and 1,945 $mOsm \cdot kg^{-1}$). If substantial amounts of carbohydrate are dumped into the intestine, one may experience abdominal bloating and osmotic diarrhea, in addition to vasomotor symptoms associated with a decrease in blood volume (23).

Total fluid intake tended to be less in individuals who consumed hypertonic beverages and experienced GI disturbance. Lower fluid intake may have resulted in dehydration. Although no indicators of fluid balance were measured, the possibility of dehydration is a distinct one, based on the extensive weight losses measured in triathletes as a result of competition (19). In fact, Kreider et al. observed heat complications, coupled with abdominal and leg cramps, in five of nine triathletes during competition (8). This further supports the suggestion that dehydration/thermal stress may, in some situations, be related to the GI symptoms observed in endurance athletes. Thermal stress during exercise may lead to an intra-/extracellular Na^+/K^+ imbalance which may be responsible for some of the observed symptoms.

Additionally, dehydration is known to decrease blood volume (20). Severe exercise reduces blood flow to the intestines (4). These two facts might also account for the increase in GI disturbance observed when exercise and dehydration are combined. A reduced blood flow may be associated with intestinal ischemia, which in turn may cause intestinal malabsorption of carbohydrates (27) and abdominal discomfort. In support of this is the fact that clinically diagnosed "intestinal angina" has been attributed to relative ischemia (3), and that gut tissue specimens of marathon runners experiencing bloody diarrhea show the same morphological changes as in the ischemic gut (22). The ingestion of a hypertonic beverage, which increases gastrointestinal secretions, results in net fluid loss from the circulation. Thus, in a dehydrated state, the ingestion of a hypertonic beverage during exercise may have an effect on blood supply to the cells of the gastrointestinal tract. The actual mechanism that causes cramping is uncertain. Whether it is ischemia, accumulated toxins, or intracellular/extracellular electrolyte imbalance that results in the symptoms observed is unclear.

Summary

Triathlon competition carries with it the same risks as marathon running in terms of gastrointestinal complications. More symptoms were reported during running than during either swimming or bicycling. Additionally, increased intake of fat, protein, and dietary fiber suggest that these specific dietary components may increase the risk of GI dysfunction. Increased beverage osmolality was also shown to be linked with GI symptoms. A possible link with dehydration was observed; the combination of hypertonic beverage consumption and low fluid intake tended to increase the prevalence of severe symptoms.

Recommendations for race-day dietary intake include sufficient nonhypertonic beverages, to prevent dehydration and avoid massive secretion into the lumen, and in general a low-fiber, low-fat, low-protein, and carbohydrate-rich diet, which supplements the limited carbohydrate reserves of the body and at the same time reduces the risk of GI symptoms.

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