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Gastric emptying in marathon runners

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SUMMARY **Radionuclide gastric emptying studies using 99m-Tc human serum albumin egg omelette have been carried out in 10 long distance runners at rest and during a 90 minute run at sustained speed. Resting values are compared with controls comprising 10 sedentary subjects. Runners show a significantly accelerated basal gastric emptying (runners t½=67·7 (5·9) min; sedentaries t½=85·3 (4·5) min, p<0·001). The exercise had no significant effect on gastric emptying in these trained subjects (exercise t½=66·8 (5·9) min, p=NS), suggesting adaptation to exercise.**

Gastric emptying studies using radiolabelled meals are a well established method to assess gastric motility and its disorders[1]. Comparatively little has been done to evaluate the effect of exercise on gastric motility, mainly because of the lack of a standard method for measuring gastric emptying during physical exercise. Early physiological studies showed that gastric secretion is inhibited during exercise;[2] depending on the severity of the exercise and on the ingestion of fluid. Contradictory data, however, have been reported,[3 4] regarding changes in gastric emptying rates of solids and liquids on exercise, depending on the methodology used.

The purpose of this investigation is to evaluate the suitability of radioisotope gastric emptying studies during physical exercise. We have studied a selected group of trained athletes to establish their gastric emptying patterns, and have compared their values with those obtained from a sedentary group of subjects.

Methods

SUBJECTS

After giving informed consent, studies were carried out at rest on 10 healthy, male volunteers, aged 27 (5) years with a body surface area (BSA) of 1·76 (0·14) m^2, and on 10 male long distance runners, aged 29 (6) years with a BSA of 1·74 (0·11) m^2 (p=NS), first at rest, and later during exercise.

The group of runners had a mean marathon (42 195 m) time of 171·2 (11·6) min. They had been running 75·3 (16·9) km per week for a period of 4·9 (2·7) years. Both groups had similar dietary habits.

PROCEDURE

After an eight hour fast, each subject ingested the test meal; a sandwich consisting of an egg omelette (white bread, 50 g; egg 50 g; olive oil 5 g), and 200 ml orange juice. The total caloric content of the meal was 400 kcal (carbohydrates: 40%; fats: 38%; proteins: 22%).

The isotope marker was 74 MBq (2 mCi) of 99m-Tc human serum albumin injected into a beaten raw egg then made into an omelette[1].

After finishing the ingestion of the test meal, each volunteer was placed in front of the camera detector (large field of view camera on line to a standard dedicated computer*). The amount of radioactivity retained in the stomach was recorded in anterior and posterior projections (to calculate geometrical means). These readings were repeated at three intervals of 30 minutes. During the time of the study, each subject could remain seated or walk within a distance limited to 5 m. All studies were done in the afternoon.

The resting procedure was carried out in the group of 10 sedentaries and in the group of runners. The runners returned to the Nuclear Medicine Department again a week later to carry out an exercise procedure as follows. After finishing the ingestion of the test meal, control detections were recorded and at the same time, while standing in front of the detector, basal heart rate and blood pressure were recorded. Immediately after, each of the subjects started to run around the hospital area at his habitual training speed. This speed oscillated between four

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*General Electric Maxill on line to a Digital PDP11/34 Gamma 11.

minutes and four and a half minutes/km, thus covering a total distance of 20 to 22·5 km in 90 minutes. The temperature at the time was 22·7°C with a humidity of 81%. Each subject returned at intervals of 30 minutes to repeat detections of gastric contents and to record constants (the whole procedure representing a pause of one minute maximum). Then they continued to run until the next control. Studies were finished after the third control (90 minutes after finishing the ingestion of the test meal).

STATISTICAL ANALYSIS

The results corrected for radioactive decay are expressed as a percentage of the initial counts in the stomach at 30, 60, and 90 minutes. In each subject the half emptying time (t½) has been calculated from the regression line of the log counts against time. Results are analysed using the two-sample *t* test to compare mean t½ values between sedentaries and runners, and the paired *t* test to compare mean t½ values before and after exercise. The comparison of the mean percentages of meal retained in stomach is based on analysis of variance.

Table *Percentages of the test meal retained in stomach and calculated t½ for all subjects*

	30 min (%)			*60 min (%)*			*90 min (%)*		
	SR	*AR*	*AE*	*SR*	*AR*	*AE*	*SR*	*AR*	*AE*
HR:	*73 (5)*	*60 (6)*	*134 (16)*			*143 (14)*			*138 (22)*
	84	71	60	62	65	36	52	46	22
	93	74	71	72	54	56	50	37	45
	99	70	83	79	54	63	61	40	28
	83	51	64	59	30	53	36	16	29
	86	59	80	71	53	57	49	39	34
	80	56	73	53	37	70	44	20	45
	90	76	70	63	57	31	48	37	20
	87	63	69	68	44	46	51	31	21
	87	64	75	67	55	61	45	54	31
	99	61	60	64	44	36	48	33	19
	–p<0·001–			–p=0·001–			–p=0·006–		
Mean:	88·8	64·5	70·5	65·8	49·3	50·9	48·4	35·3	29·4
(SD)	6·4	8·1	8·3	7·3	10·6	13·0	6·3	11·2	9·7
Mean t½ (min):							85·3	67·7	66·8
(SD):							4·5	5·9	4·5
							–p<0·001–		

SR: Sedentaries at rest. AR: Athletes at rest. AE: Athletes at exercise. HR: Heart rate in beats per minute.

Results

At rest, the mean percentages of the solid component of the meal retained in stomach fit a linear model with a t½=85·3 (4·5) min in the sedentary group and a t½=67·7 (5·9) min in the runners (p<0·001). On exercise the runners had a t½=66·8 (5·9) (p=NS) (Figs 1, 2).

Comparing the mean percentages of retention at the three intervals studied, between sedentaries and runners at rest. The latter emptied their stomach considerably faster, with a significance at all intervals (Table). We did not, however, find a difference in the runners when exercising (Table), despite a tendency of slower emptying at 30 minutes.

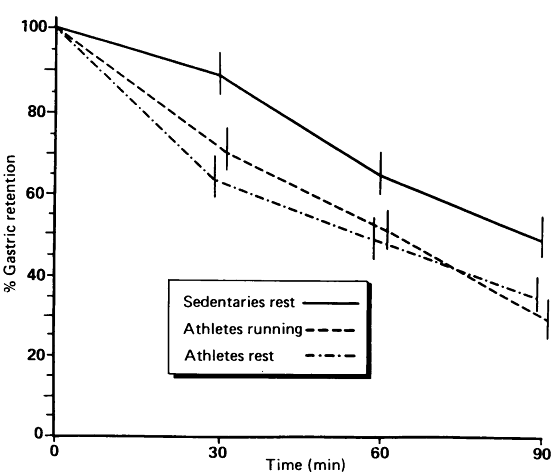

Fig 1 *Mean (SD) % retention values for the solid component of the meal. Comparison between sedentaries and long distance runners.*

Resting heart rate in the sedentary group was 73 (5·2) beats per minute (bpm) and 60·2 (6·7) bpm (p<0·01) in the runners. Heart rate increased from 60·2 (6·7) bpm to 143 (14·6) bpm registered at the second control (70% of the maximal heart rate predicted for the age), and remained generally constant during the exercise protocol (Table). Diastolic blood pressure decreased as the exercise proceeded (76 (19) mmHg at rest and 68 (7) mmHg at 90 min, p<0·01) probably in relationship to the decrease in peripheral resistance in prolonged and sustained running.

Discussion

In this study the values for gastric emptying in the group of sedentaries are similar in pattern to those that were reported previously[5] when validating the same methodology but using a test meal of 530 Kcal, finding a longer t½ (113 min) in male subjects.

In our first study[5] we reported that women emptied their stomach significantly slower than men; regardless of age, weight of body surface, but in relationship with the phase of the menstrual cycle. Other factors known to influence gastric emptying are smoking[6] and the time of the day at which the study is carried

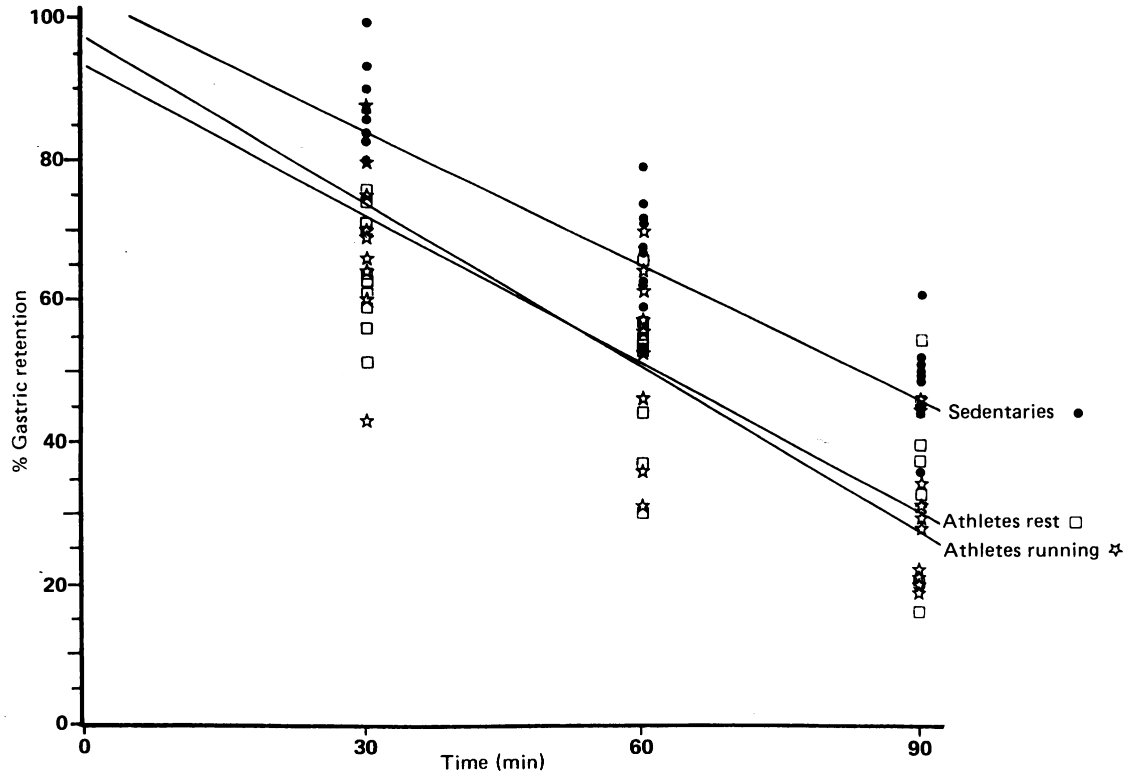

Fig 2 *Linear regression analysis. Sedentaries: slope=−0·591; intercept=102·4; corr coef=−0·992. Athletes at rest: Slope=−0·696; Intercept=93·5; corr coef=−0·917. Athletes running: Slope=0·77; Intercept=97·8; corr coef=−0·944.*

out.[7] We therefore selected two homogeneous groups of male subjects, non-smokers, with similar body surface,[8] no history of gastrointestinal disease and similar dietary habits, one of sedentaries and other of long distance runners.

99m-Tc human serum albumin egg as a marker of the solid phase of the gastric content has shown sufficient stability[1] for gastric emptying studies lasting less than three hours. Geometric mean correction from anterior and posterior projection is necessary to avoid substantial underestimation of gastric emptying.[9]

Early studies using aspiration of gastric content[2] or barium impregnated meal,[3] suggested that gastric emptying was accelerated by moderate exercise. Cammack[10] recently studied seven volunteers (six women) during intermittent pedalling after a test meal labelled with a semisolid marker and found a shorter t½ when exercising (1·5 (0·1) h at a heart rate of 72 (1) bpm at rest *versus* 1·2 (0·1) h at 117 (1) bpm on exercise).

In our study, exercise did not accelerate gastric emptying in young male runners. They showed a basal gastric emptying significantly faster than sedentaries. Our exercise model, however, is quite different from the one used by Cammack and our subjects maintained a higher heart rate level during exercise. The pattern of faster basal gastric emptying time is consistent with a dominant parasympathetic tone in this group of runners. Athletic training is known to produce a dominant parasympathetic tone.[11] The resting bradycardia of athletic training is caused by a decrease in the influence of cardiac sympathetics on the pacemaker with no change in the vagal influence,[12] producing a greater vagal predominance. We previously reported low basal cathecolamine and dopamine concentrations in plasma in a similar group of trained athletes.[13] These substances tend to produce a delay in gastric emptying.

Exercise is known to cause the release of a variety of hormones and transmitter substances and many of the physiological effects of exercise are mediated by the release of cathecolamines which are expected to cause delay in gastric emptying.[14]

As with psychological stress or acute centrally acting stimuli,[15 16] however, it is possible that physical exercise could produce variable effects on gastric emptying depending on the dominance of sympathetic or parasympathetic tone. It is also known that physical exercise produces the release of opiate like agents into the peripheral blood[17] which may interact with receptors in the gastrointestinal tract and influence gastric motility, but tending also to delay gastric emptying.

We have used a model of sustained but not exhausting exercise. Severe and exhausting exercise has been reported to produce a delay in gastric emptying[2 3] possibly induced by a dominant sympathetic effect.

In conclusion, gastric emptying studies using radiolabelled test meal seem well suited to study the influence of physical exercise on gastric motility. Subjects with a prolonged running habit show a pattern of significant accelerated gastric emptying, which does not seem to be affected by their habitual sustained exercise. This may suggest an adaptation process of gastric motility with exercise. Further studies must be done to assess the influence of progressive physical exercise producing exhaustion on gastric motility.

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