

# Effects of meal volume and posture on gastric emptying of solids and appetite

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**Doran, Selena, Karen L. Jones, Jane M. Andrews, and Michael Horowitz.** Effects of meal volume and posture on gastric emptying of solids and appetite. *Am. J. Physiol. 275 (Regulatory Integrative Comp. Physiol. 44): R1712–R1718, 1998.*—The effects of volume and posture on gastric emptying and intragastric distribution of a solid meal and appetite were evaluated. Eight normal volunteers were studied on four occasions, on each of which a meal comprising ground beef mixed with tomato sauce of either 650 g (“large”) or 217 g (“small”) was eaten. Two studies were performed while the subject was lying in the left lateral decubitus position, and two studies were performed while the subject was sitting so that in each subject data were available for both meals and in both postures. Hunger and fullness were evaluated using a visual analog questionnaire. In both postures and after both meals, gastric emptying approximated a linear pattern after an initial lag phase. The lag phase was shorter for the large meal when compared with the small meal [sitting: large  $13 \pm 5$  vs. small  $29 \pm 7$  min; left lateral: large  $16 \pm 3$  vs. small  $24 \pm 3$  min,  $F(1,7) = 46.3$ ,  $P < 0.0005$ ]. In both postures the contents of the total [ $F(1,7) = 1794.5$ ,  $P < 0.0001$ ], proximal [ $F(1,7) = 203.7$ ,  $P < 0.0001$ ], and distal [ $F(1,7) = 231.5$ ,  $P < 0.0001$ ] stomach were greater after the large meal when compared with the small meal. Although the 50% emptying time was greater with the large than the small meal [ $F(1,7) = 40.8$ ,  $P < 0.001$ ], the postlag emptying rate (g/min) was more rapid with the large meal [sitting: large  $1.7 \pm 0.2$  vs. small  $1.1 \pm 0.1$  g/min; left lateral: large  $1.8 \pm 0.1$  vs. small  $1.3 \pm 0.04$  g/min,  $F(1,7) = 44.7$ ,  $P < 0.0005$ ]. There was a significant interaction between meal volume and posture for retention in the distal stomach [ $F(1,7) = 7.14$ ,  $P < 0.05$ ]. Contrasts were used to evaluate the effects of volume and posture between the four studies and demonstrated an effect of posture for the large [ $F(1,21) = 18.7$ ,  $P < 0.005$ ] but not the small [ $F(1,21) = 0.30$ ,  $P = 0.60$ ] meal so that the retention was greater in the sitting when compared with the left lateral position. The magnitude of the postprandial increase in fullness [ $F(1,7) = 7.8$ ,  $P < 0.05$ ] and reduction in hunger [ $F(1,7) = 5.9$ ,  $P < 0.05$ ] was greater with the large meal. We conclude that meal volume has a major effect on gastric emptying; in contrast posture has only a minor impact on intragastric meal distribution, which is observed only after a large meal, and no effect on gastric emptying.

gravity; intragastric meal distribution; small intestinal feedback

THERE IS RELATIVELY little information about the effects of alterations in meal composition or volume on the rate of gastric emptying. The emphasis of most previous studies has been on gastric emptying of liquids, which has been demonstrated to be affected by propulsive forces generated by intragastric volume and by gravity (1, 4, 14, 16, 17), as well as feedback from receptors in the small intestinal lumen (3, 20, 22). In dogs, it has been suggested that the time taken to grind solid food into small particles, so-called trituration, is the major

factor regulating its emptying (21), implying that gastric emptying of solids, unlike that of liquids, is not “load-dependent” and that digestible solids normally empty from the stomach at a maximum rate (21). However, this hypothesis has not been tested in humans. In humans, the potential effects of posture and meal volume on gastric emptying of solids has hitherto only been assessed with mixed solid/liquid meals (7, 23, 24), and it is clear that the presence of liquid may modulate the rate of emptying of a solid meal (6, 8, 15).

Satiety signals from the gastrointestinal tract, triggered by gastric distension, and the interaction of nutrients with small intestinal receptors are important in the regulation of appetite (7, 9, 10, 19, 26, 27). There is some evidence that postprandial appetite may be influenced by posture, an effect that may be mediated by changes in intragastric meal distribution or the rate of gastric emptying (14).

The purpose of this study was to evaluate the effects of meal volume and posture on gastric emptying and intragastric distribution of a solid meal and appetite in normal subjects.

## MATERIALS AND METHODS

### Subjects

Eight healthy male volunteers, mean age 24 yr (range 18–34 yr) and mean body mass index  $23.5 \text{ kg/m}^2$  ( $20.5\text{--}27.9 \text{ kg/m}^2$ ), were studied. All subjects were nonsmokers on no medication, and none had a history of gastrointestinal disease or surgery. Written, informed consent was obtained from each subject, and the protocol was approved by the Human Ethics Committee of the Royal Adelaide Hospital.

### Protocol

Each subject had measurements of gastric emptying and appetite on 4 days, each of which was separated by 2–14 days. Two of the four studies were performed while the subject was lying in the left lateral decubitus (“pylorus up”) position, and two were performed while the subject was sitting. In both postures gastric emptying of a “large” and a “small” meal were quantified. The order of the four studies was randomized. The large meal (total weight 650 g) consisted of 450 g cooked ground beef with in vivo labeled  $^{99m}\text{Tc}$ -chicken liver and 200 g tomato sauce (“Dolmio”; Master Foods, Wyong, NSW, Australia), and the small meal (total weight 217 g) consisted of 150 g ground beef with  $^{99m}\text{Tc}$ -chicken liver and 67 g sauce. The caloric content of the large meal was 1,302 kcal, and that of the small meal was 434 kcal. Each meal was consumed at 1200 after an overnight fast (12 h liquids and 14 h solids) in front of a scintillation camera (6). Subjects were asked not to chew before swallowing (in an attempt to standardize particle size) and to consume the meal within 5 min. The time for meal consumption was measured. Immediately before, and after, meal consumption appetite was assessed using a visual analog questionnaire (28). Both gastric emptying and appe-

tite were quantified for 240 min after ingestion of the test meal.

#### Measurement of Gastric Emptying

In vivo labeled  $^{99m}\text{Tc}$ -sulfur colloid-chicken liver (20 MBq; ~5 g) was mixed thoroughly with uncooked ground beef (so that the combined weight was 450 or 150 g) and then cooked. The tomato sauce (200 or 67 g) was added after cooking and mixed through the meat.

Scintigraphic data were acquired for 240 min, at 1-min frames for the first 60 min and at 3-min frames thereafter. Data acquisition commenced immediately after meal consumption. Radionuclide data were corrected for radionuclide decay, gamma ray attenuation, and subject movement using established methods (6–8). The total stomach region of interest was divided into proximal and distal regions, with the proximal region corresponding to the fundus and proximal corpus and the distal region corresponding to the distal corpus and antrum (8). Emptying curves were derived for the total, proximal, and distal stomach regions of interest and were expressed as percent of isotope retained vs. time (7, 8). From the emptying curves, a number of parameters were then calculated for further analysis. For the total stomach these were the lag phase [defined as the time period, in minutes, before any of the meal entered the proximal small intestine (6)], the amount of isotope remaining in the stomach at 15-min intervals until 60 min and at 30-min intervals until 240 min, the postlag linear emptying rate (g/min; between the end of the lag phase and 180 min), and the 50% emptying time ( $T_{50}$ ). The content of both the proximal and distal stomach at 15-min intervals until 240 min and the rate of emptying from the proximal stomach (g/min; between 0 and 180 min) were also calculated (7).

**Assessment of appetite.** Hunger and fullness were evaluated by having the subjects mark a previously validated visual analog scale at -15, 0, 15, 30, 45, 60, 90, 120, 150, 180, 210, and 240 min (28).

**Statistical analysis.** A two-factor (meal volume and body posture) repeated measures ANOVA was used to evaluate effects of meal size and posture on single value variables such as the time for meal consumption, the lag phase, the  $T_{50}$ , and the postlag emptying rate. A three-factor (meal volume, body posture, and time) repeated-measures ANOVA was performed to evaluate effects on gastric emptying from the total, proximal, and distal stomach, fullness, and hunger. The following time points were used in the three-factor ANOVA: 0, 15, 30, 45, 60, 90, 120, 150, 180, 210, and 240 min. When a significant interaction between factors was observed, contrasts were used to test preplanned hypotheses of interest enabling paired comparisons between the four studies. Relationships between hunger, fullness, and gastric emptying were assessed using linear regression analysis at 0, 15, 30, 45, 60, 90, 120, 150, 180, 210, and 240 min. All data were analyzed using proprietary software SuperANOVA (version 1.11; Abacus Concepts, Berkeley, CA). Data are shown as mean values  $\pm$  SE. A  $P$  value  $<0.05$  was considered significant in all analyses.

## RESULTS

All subjects tolerated the study well, and no adverse affects were reported.

#### Time Taken For Meal Consumption

In 5 of the 32 studies the time for meal consumption was  $>5$  min (maximum 9 min). The time taken for

consumption of the large meal was greater than that for the small meal in both postures, and the magnitude of the effect of meal size was not modified by posture (sitting: large  $5.4 \pm 0.6$  min vs. small  $2.3 \pm 0.3$  min; left lateral: large  $5.4 \pm 0.7$  min vs. small  $1.8 \pm 0.2$  min). Repeated-measures ANOVA demonstrated a significant effect of meal size [ $F(1,7) = 46.3$ ,  $P < 0.0005$ ], a nonsignificant effect of posture [ $F(1,7) = 0.76$ ,  $P = 0.41$ ], and a nonsignificant interaction of meal size and posture [ $F(1,7) = 1.99$ ,  $P = 0.20$ ].

#### Gastric emptying

**Lag phase.** In both postures gastric emptying approximated a linear pattern after an initial lag phase (Fig. 1). The lag phase was shorter for the large meal when compared with the small meal (sitting: large  $13 \pm 5$  min vs. small  $29 \pm 7$  min; left lateral: large  $16 \pm 3$  min vs. small  $24 \pm 3$  min), and the magnitude of the effect of meal volume was not modified by posture. Repeated-measures ANOVA demonstrated a significant effect of meal volume [ $F(1,7) = 15.1$ ,  $P < 0.01$ ], a nonsignificant effect of posture [ $F(1,7) = 0.05$ ,  $P = 0.83$ ], and a nonsignificant interaction between meal size and posture [ $F(1,7) = 2.42$ ,  $P = 0.16$ ].

**$T_{50}$ .** The  $T_{50}$  was longer with the large meal than the small meal and was not influenced by body posture (sitting: large  $197 \pm 10$  min vs. small  $121 \pm 19$  min; left lateral: large  $202 \pm 12$  min vs. small  $133 \pm 14$  min). Repeated-measures ANOVA demonstrated a significant effect of meal volume [ $F(1,7) = 40.8$ ,  $P < 0.001$ ] but not posture [ $F(1,7) = 0.79$ ,  $P = 0.40$ ], and there was no interaction between meal volume and posture [ $F(1,7) = 0.32$ ,  $P = 0.59$ ].

**Postlag emptying rate.** The postlag emptying rates were also more rapid with the large meal, an effect not influenced by body posture (sitting: large  $1.7 \pm 0.2$  g/min vs. small  $1.1 \pm 0.1$  g/min; left lateral: large  $1.8 \pm 0.1$  g/min vs. small  $1.3 \pm 0.04$  g/min). Repeated-measures ANOVA demonstrated a significant effect of meal volume [ $F(1,7) = 44.7$ ,  $P < 0.0005$ ] but not posture [ $F(1,7) = 2.4$ ,  $P = 0.17$ ], and there was no interaction between meal volume and posture [ $F(1,7) = 0.65$ ,  $P = 0.45$ ].

**Total stomach.** The amount of the meal (g) in the total stomach was greater with the large meal compared with the small meal and was not influenced by posture (Fig. 1). Repeated-measures ANOVA demonstrated a significant effect of meal volume [ $F(1,7) = 1794.5$ ,  $P < 0.0001$ ], no significant effect of body posture [ $F(1,7) = 0.001$ ,  $P = 0.98$ ], a significant effect of time [ $F(10,70) = 218.9$ ,  $P < 0.0001$ ], no significant interaction between meal volume and posture [ $F(1,7) = 0.34$ ,  $P = 0.57$ ], a significant interaction between meal volume and time [ $F(10,70) = 50.9$ ,  $P < 0.0001$ ], and a nonsignificant interaction between meal volume, posture, and time [ $F(10,70) = 2.28$ ,  $P = 0.11$ ].

There was also a greater percentage of the meal retained in the total stomach with the large meal (Fig. 2). Repeated-measures ANOVA demonstrated a significant effect of meal volume [ $F(1,7) = 28.4$ ,  $P < 0.001$ ], a nonsignificant effect of body posture [ $F(1,7) =$

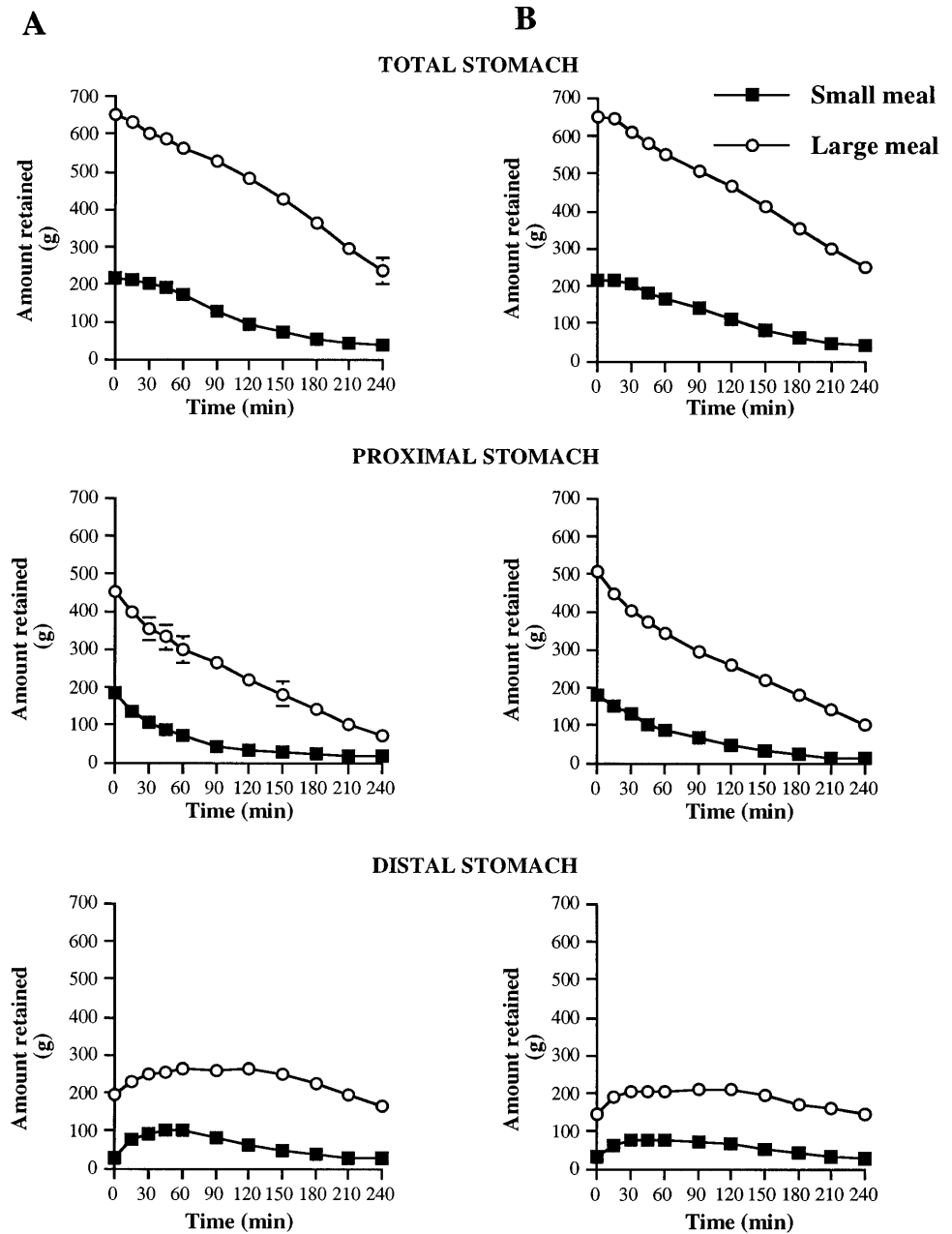


Fig. 1. Gastric emptying (g) and intra-gastric distribution of small (217 g) and large (650 g) meals in the sitting (A) and left lateral (B) positions. Data are mean values  $\pm$  SE [small vs. large meal: total,  $F(1,7) = 1794.5$ ,  $P < 0.0001$ ; proximal,  $F(1,7) = 203.7$ ,  $P < 0.0001$ ; distal,  $F(1,7) = 231.5$ ,  $P < 0.0001$ ].

0.06,  $P = 0.81$ ], a significant effect of time [ $F(10,70) = 203.7$ ,  $P < 0.0001$ ], a nonsignificant interaction between meal volume and posture [ $F(1,7) = 0.51$ ,  $P = 0.50$ ], a significant interaction between meal volume and time [ $F(10,70) = 18.7$ ,  $P < 0.0001$ ], and a nonsignificant interaction between meal volume, posture, and time [ $F(10,70) = 1.70$ ,  $P = 0.20$ ].

**Proximal stomach.** The amount of the meal (g) in the proximal stomach was greater with the large meal compared with the small meal and was not influenced by posture (Fig. 1). Repeated-measures ANOVA demonstrated a significant effect of meal volume [ $F(1,7) = 203.7$ ,  $P < 0.0001$ ], a nonsignificant effect of body posture [ $F(1,7) = 3.30$ ,  $P = 0.11$ ], a significant effect of time [ $F(10,70) = 309$ ,  $P < 0.0001$ ], a nonsignificant

interaction between meal volume and posture [ $F(1,7) = 2.30$ ,  $P = 0.17$ ], a significant interaction between meal volume and time [ $F(10,70) = 85.7$ ,  $P < 0.0001$ ], and a nonsignificant interaction between meal volume, posture, and time [ $F(10,70) = 0.79$ ,  $P = 0.49$ ].

There was a greater percentage of the meal retained in the proximal stomach with the large meal (Fig. 2). Repeated-measures ANOVA demonstrated a significant effect of meal volume [ $F(1,7) = 14.4$ ,  $P < 0.01$ ], a nonsignificant effect of body posture [ $F(1,7) = 2.73$ ,  $P = 0.14$ ], a significant effect of time [ $F(10,70) = 272.5$ ,  $P < 0.0001$ ], a nonsignificant interaction between meal volume and posture [ $F(1,7) = 0.23$ ,  $P = 0.65$ ], a significant interaction between meal volume and time [ $F(10,70) = 18.7$ ,  $P < 0.0001$ ], and a nonsignificant

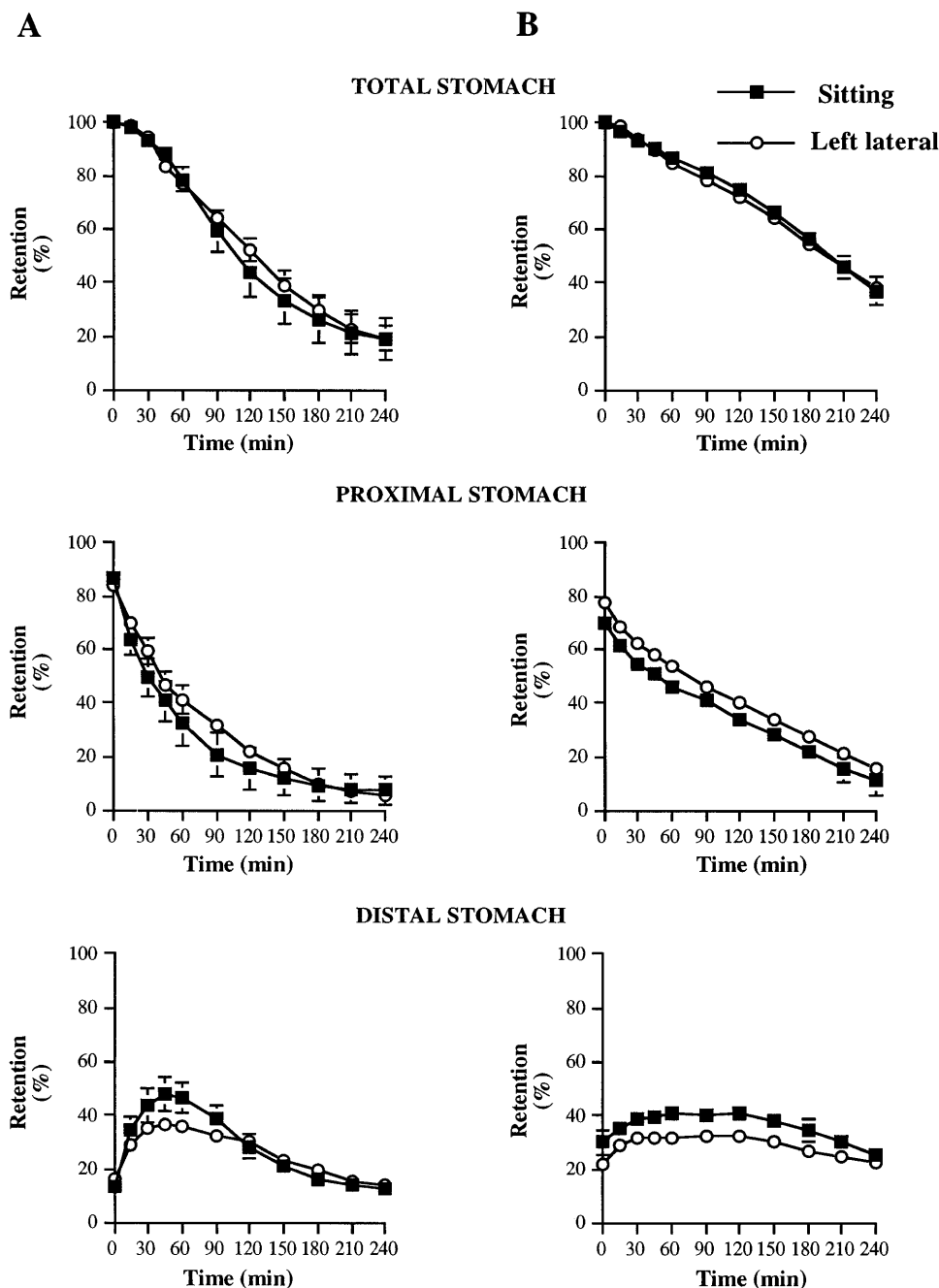


Fig. 2. Effect of posture on gastric emptying and intragastric distribution of small (217 g) and large (650 g) meals in the sitting (A) and left lateral (B) positions. Data are mean values  $\pm$  SE and are shown as a percentage of maximum [sitting vs. left lateral: total,  $F(1,7) = 0.06$ ,  $P = 0.81$ ; proximal,  $F(1,7) = 2.73$ ,  $P = 0.14$ ; distal,  $F(1,7) = 5.7$ ,  $P < 0.05$ ].

interaction between meal volume, posture, and time [ $F(10,70) = 1.66$ ,  $P = 0.22$ ].

**Distal stomach.** The amount of the meal (g) in the distal stomach was greater with the large meal compared with the small meal and also was greater in the sitting compared with the left lateral position (Fig. 1). Repeated-measures ANOVA demonstrated a significant effect of meal volume [ $F(1,7) = 231.5$ ,  $P < 0.0001$ ], a significant effect of body posture [ $F(1,7) = 7.3$ ,  $P < 0.05$ ], a significant effect of time [ $F(10,70) = 13.5$ ,  $P < 0.005$ ], a significant interaction between meal volume and posture [ $F(1,7) = 7.14$ ,  $P < 0.05$ ], a nonsignificant interaction between meal volume and time [ $F(10,70) = 3.0$ ,  $P = 0.07$ ], and a nonsignificant interaction between

meal volume, posture, and time [ $F(10,70) = 1.29$ ,  $P = 0.30$ ]. Given the significant interaction of meal volume and body posture, contrasts were performed to further evaluate the effects. There was a significant effect of meal volume on the amount of the meal in the distal stomach for both postures ["sitting":  $F(1,21) = 246.4$ ,  $P < 0.001$ ; "left lateral":  $F(1,21) = 142.1$ ,  $P < 0.0001$ ]. In contrast, the effects of posture were only evident with the large meal [ $F(1,21) = 18.7$ ,  $P < 0.005$ ] but not with the small meal [ $F(1,21) = 0.30$ ,  $P = 0.60$ ].

There was also a greater percentage of the meal retained in the distal stomach with the large meal and more retained in the sitting position compared with the left lateral position (Fig. 2). Repeated-measures ANOVA



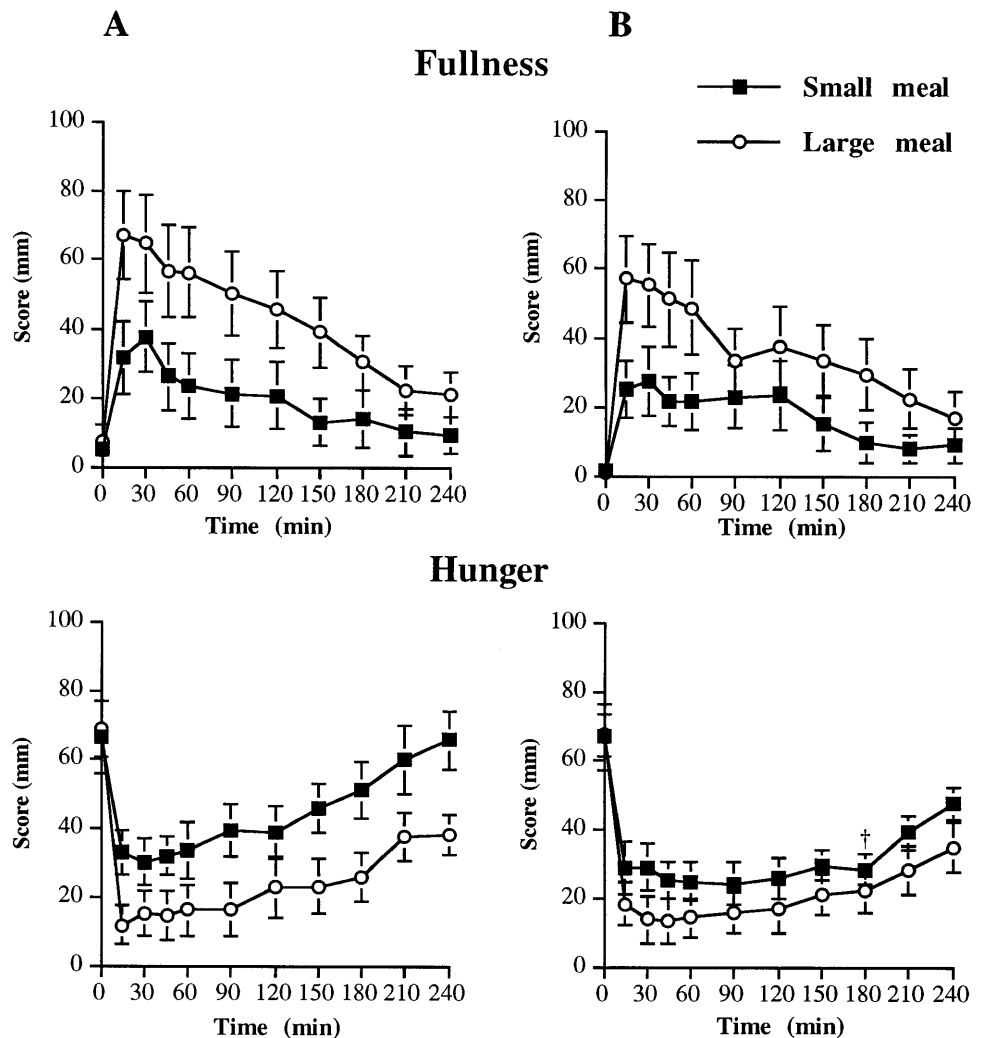


Fig. 3. Perceptions of hunger and fullness immediately before and after ingestion of small (217 g) and large (650 g) meals in the sitting (A) and left lateral (B) positions. Data are mean values  $\pm$  SE [small vs. large meal: fullness,  $F(1,7) = 7.8$ ,  $P < 0.05$ ; hunger,  $F(1,7) = 5.9$ ,  $P < 0.05$ ].

demonstrated a significant effect of meal volume [ $F(1,7) = 49.9$ ,  $P < 0.0005$ ], a significant effect of body posture [ $F(1,7) = 5.7$ ,  $P < 0.05$ ], a significant effect of time [ $F(10,70) = 15.9$ ,  $P < 0.005$ ], a nonsignificant interaction between meal volume and posture [ $F(1,7) = 3.09$ ,  $P = 0.12$ ], a significant interaction between meal volume and time [ $F(10,70) = 10.3$ ,  $P < 0.005$ ], and a nonsignificant interaction between meal volume, posture, and time [ $F(10,70) = 2.99$ ,  $P = 0.055$ ].

#### Appetite

There was no difference between the four studies in scores for hunger or fullness before meal ingestion.

**Fullness.** In both postures there was an increase in fullness after both meals. The score for fullness was greater with the large than the small meal and was not influenced by body posture (Fig. 3). Repeated-measures ANOVA demonstrated a significant effect of meal volume [ $F(1,7) = 7.8$ ,  $P < 0.05$ ], a nonsignificant effect of body posture [ $F(1,7) = 3.2$ ,  $P = 0.12$ ], a significant effect of time [ $F(10,70) = 14.5$ ,  $P < 0.001$ ], a nonsignificant interaction between meal volume and posture [ $F(1,7) = 0.59$ ,  $P = 0.47$ ], a significant interaction between meal

volume and time [ $F(10,70) = 5.1$ ,  $P < 0.05$ ], and a nonsignificant interaction between meal volume, posture, and time [ $F(10,70) = 0.89$ ,  $P = 0.46$ ].

**Hunger.** In both postures there was a reduction in hunger after both meals. The magnitude of these changes was greater with the large than the small meal and greater in the sitting position compared with the left lateral position (Fig. 3). Repeated measures ANOVA demonstrated a significant effect of meal volume [ $F(1,7) = 5.9$ ,  $P < 0.05$ ], an almost significant effect of body posture [ $F(1,7) = 5.3$ ,  $P = 0.055$ ], a significant effect of time [ $F(10,70) = 13.4$ ,  $P < 0.001$ ], a nonsignificant interaction between meal volume and posture [ $F(1,7) = 1.93$ ,  $P = 0.21$ ], a nonsignificant interaction between meal volume and time [ $F(10,70) = 1.7$ ,  $P = 0.22$ ], and a nonsignificant interaction between meal volume, posture, and time [ $F(10,70) = 0.88$ ,  $P = 0.49$ ].

**Relationship between appetite and gastric emptying.** Hunger and fullness were inversely related ( $r \geq -0.73$ ,  $P < 0.05$ ) at all time points after the meal up to 180 min.

There were no significant relationships between scores for either fullness or hunger and the content of the total or proximal stomach. After the large meal the

score for hunger at 210 min was inversely related to the content of the distal stomach at that time ( $r = 0.72$ ,  $P < 0.05$ ) but not at any other time point.

## DISCUSSION

This study establishes for the first time that gastric emptying of a solid meal is influenced by its volume. A threefold increase in the volume of a solid meal (from 217 to 650 g) was associated with a reduction in the duration of the lag phase and acceleration of the postlag emptying rate. As a consequence of these changes the rate of energy delivery from the stomach to the small intestine was much faster with the larger meal. In contrast to the effects of volume, posture had only a minor (albeit statistically significant) impact on intragastric meal distribution and no effect on the rate of gastric emptying. Although the demonstration that meal volume was a major determinant of postprandial satiation is predictable, the observation that after ingestion of the large meal hunger was inversely related to the content of the distal stomach is of interest.

The effect of the volume of a solid meal on its rate of gastric emptying has hitherto not been evaluated in humans. In dogs, Lin et al. (21) reported that the rate of emptying of 10-mm pieces of steak was independent of meal volume in the range of 150–600 g and accordingly suggested that trituration was the rate-limiting step for solid emptying. It should, however, be noted that in this study chyme was diverted from the small intestine by a duodenal fistula, thereby eliminating small intestinal feedback. It has been clearly established in humans that increasing the volume of a liquid meal is associated with more rapid emptying (21), even if the liquid contains nutrients (17), indicating that with liquids intragastric volume has the capacity to act as a propulsive force sufficient to overcome feedback from small intestinal chemoreceptors (3, 20, 22). In contrast, studies assessing the effects of meal volume on gastric emptying of solids in humans have been conducted only using mixed solid/liquid meals. Moore et al. (24) assessed the relative influence of weight and caloric content on gastric emptying of a mixed meal using a scintigraphic technique, but interpretation of their results is difficult, as the major energy component of their meal (oil) was not labeled. We have previously reported (7) that an increase in the volume of the solid component of a mixed solid and liquid meal is associated with more rapid emptying of solids, from both the total and proximal stomach. In this study (7) the lag phase was longer after the larger meal, confirming that the presence of a nutrient liquid modifies emptying of the solid component of a meal (6, 15). The mechanisms mediating the observed volume-related acceleration of gastric emptying of solids are uncertain. The amount of solid in the distal stomach was greater with the larger meal in both postures, and it has been suggested that greater antral distension may increase antral contractile activity, leading to more efficient trituration (13, 24). The shorter lag phase with the larger meal may be attributable to more efficient antral mixing (29). If this is the case the relationship between volume and empty-

ing of a solid meal is likely to be critically dependent on the time required for trituration (12, 21). It should also be recognized that after the lag phase much of the solid meal has been ground to small particles and therefore essentially liquefied. This is likely to contribute to the observed effect of meal volume on the postlag emptying rate.

Our study indicates that posture does not affect gastric emptying of a solid meal. The emphasis of most previous studies of the effects of posture on gastric emptying has related to emptying of liquids (nonnutrient, nutrient, and oil; see Refs. 1, 2, 4, 16); gastric emptying and intragastric distribution of liquids, semi-solids, and oil are affected by posture, being slower in the recumbent than the erect position (1, 2, 4, 11, 16). The effects of posture on gastric emptying of liquids is likely to relate to changes in antropyloric motility as well as passive forces generated by volume and gravity (1). Moore et al. (23) evaluated the effects of posture on gastric emptying of a meal consisting of beef stew and orange juice. Although gastric emptying of the solid component was observed to be slower in the supine when compared with the sitting and standing positions, emptying of the liquid component of the meal was not quantified, and this could account for the observed differences in gastric emptying of solid (6, 15). Our study is therefore the first to evaluate the effects of posture on gastric emptying of a solid meal in the absence of liquid. We anticipated that emptying of solids may be more rapid in the sitting than the left lateral position, but this proved not to be the case, probably because the observed effects of posture on intragastric distribution of solids were relatively small. We are uncertain why gravity does not have a major effect on intragastric distribution of solids, as it does for liquids (1, 14). Moore et al. (25) have suggested that the so-called "midgastric band" may limit movement of solid food from the proximal to the distal stomach. It is also possible that antral tone regulates intragastric distribution of solids (8).

Signals from the gastrointestinal tract play a major role in the regulation of appetite (27), but it has not been established whether gastric distension or feedback from small intestinal nutrient receptors is the more important of these mechanisms (5, 9, 10, 14, 18, 19, 26). The potential effects of posture on appetite and gastrointestinal symptoms are of some interest; patients with upper gastrointestinal symptoms frequently report that improvement occurs with standing or sitting. We have reported previously that after ingestion of an oil/aqueous meal, postprandial hunger is influenced by posture, being less in the left lateral decubitus than the sitting position (14). In the current study postprandial appetite was less after the larger meal in both postures, for at least the first four hours after eating. This difference was apparent soon after ingestion of the meal, indicative of an effect mediated, at least initially, by greater intragastric volume, rather than more rapid gastric emptying. We, however, cannot exclude the possibility that the more rapid emptying of the larger meal, and thus greater stimulation of small

intestinal nutrient receptors, contributed to the sustained increase in satiation. There was a trend for postprandial hunger to be less in the left lateral than the sitting position after ingestion of the small meal, but the magnitude of this difference was small, and the effect was not quite significant. It is therefore likely that the reduction in hunger in the left lateral position after ingestion of an oil/aqueous meal reported in our previous study relates to the more rapid emptying of oil in this posture (14). An inverse relationship between postprandial hunger and the content of the distal stomach was observed; however, this relationship was only evident at one time point and is likely to represent a statistical artifact.

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