Effects of ginger on gastric emptying and motility in healthy humans

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Objective **Ginger has been reported to improve upper gastrointestinal symptoms. Little information about the effects of ginger on gastric motor function, exists, however. Our aim was to investigate the effects of ginger on gastric emptying, antral motility, proximal gastric dimensions, and postprandial symptoms.**

Methods **Twenty-four healthy volunteers were studied twice in a randomized double-blind manner. After an 8 h fast, the volunteers ingested three ginger capsules (total 1200 mg) or placebo, followed after 1 h by 500 ml low-nutrient soup. Antral area, fundus area and diameter, and the frequency of antral contractions were measured using ultrasound at frequent intervals over 90 min, and the gastric half-emptying time was calculated from the change in antral area. Gastrointestinal sensations and appetite were scored using visual analog questionnaires. Data are expressed in terms of mean ± standard error.**

Results **Antral area decreased more rapidly ($P<0.001$) and the gastric half-emptying time was less after ginger than placebo ingestion (13.1 ± 1.1 vs. 26.7 ± 3.1 min, $P<0.01$), whereas the frequency of antral contractions was greater ($P<0.005$). Fundus dimensions did not differ, and there was no significant difference in any gastrointestinal symptoms.**

Conclusion **Ginger accelerates gastric emptying and stimulates antral contractions in healthy volunteers. These effects could potentially be beneficial in symptomatic patient groups.** ***Eur J Gastroenterol Hepatol*** **20:436–440 © 2008 Wolters Kluwer Health | Lippincott Williams & Wilkins.**

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Introduction

Ginger (*Zingiber officinale*), widely used in foods as a spice, is also a traditional Chinese herbal remedy, which has been used to treat a number of medical conditions including those affecting the digestive tract [1]. Around the world, ginger is a household remedy for dyspepsia, flatulence, abdominal discomfort, and diarrhea. It also has been used to reduce the symptoms of nausea and vomiting in pregnancy, motion sickness, or the post-operative setting [2–5], but the mechanisms responsible for its therapeutic effect are not well understood.

Ginger has been reported to reverse the delay in gastric emptying induced by pyrogallol [6] or cisplatin [7] in rats, to accelerate gastrointestinal transit in mice [8], and to stimulate antral contractions in dogs [9]. Accelerated gastric emptying could potentially ameliorate gastrointestinal symptoms, such as fullness or bloating, by reducing antral distension. For example, antral area is related to postprandial fullness in healthy volunteers [10–12] and to bloating in patients with functional dyspepsia; [10] in the latter group, antral width diminished on treatment with cisapride. Micklefield *et al.* [13] reported that gastric motility, measured by stationary manometry in healthy humans, was stimulated by ginger in both the fasting and postprandial states, but neither Phillips *et al.* [14] nor Stewart *et al.* [15] could demonstrate an effect of ginger on the rate of gastric emptying. The former study, however, evaluated gastric emptying by the absorption of paracetamol with no accompanying nutrient load, whereas the latter study used a low-nutrient drink (75 kcal) in only eight volunteers. To our knowledge, the effects of ginger on the proximal stomach have never been examined.

Scintigraphy represents the 'gold standard' for measuring the rate of gastric emptying [16], but entails radiation exposure. Ultrasound has emerged as an alternative method of assessing gastric emptying of liquids, and correlates well with both scintigraphy [17] and the volume of liquid that can be aspirated from the stomach, and is reproducible [18]. Furthermore, ultrasound provides a means of evaluating dimensions of both the proximal stomach and the antrum [17,19–25] as well as the frequency of antral contractions [19].

The aim of this study was to evaluate the effects of ginger on gastric emptying, dimensions of the proximal stomach and antrum, and the frequency of antral contractions, together with gastrointestinal symptoms that appear after a nutrient liquid meal in healthy humans.

Methods

Patients

Twenty-four healthy male volunteers (median age 21 years, range 19–26; median body mass index 21.7 kg/m^2, range 18–25) were recruited by advertisement. No volunteer had a history of gastrointestinal disease or used regular medication and none consumed more than 20 g alcohol daily, or was a smoker. All volunteers gave written, informed consent, and the protocol was approved by the Research Ethics Committee of the Chang Gung Memorial Hospital, Kaohsiung Medical Center.

Protocol

Each volunteer was studied on two afternoons, separated by at least 7 days, in a randomized, double-blind order. Following a fast of 8 h for solids and liquids, the volunteers ingested three capsules containing in total 1200 mg ginger root powder (Ginger Root, Nature's Way Products Inc., Springville, Utah, USA), or three identical placebo capsules containing starch, together with 50 ml of water. One hour later, volunteers consumed 500 ml of chicken and corn soup (United Kanboo, Taipei, Taiwan), containing 118.6 kcal (2.6 g protein, 2.6 g fat, 21.2 g carbohydrate). The soup was boiled and subsequently cooled to 37°C and was consumed over 5 min ($t = -5$–0 min).

Ultrasonographic scanning was performed before commencing the study to ensure a fasting motility pattern (phase I or early phase II of the migrating motor complex) by noting the absence of both fed state contractions and visible content in the stomach. The transducer was positioned in the epigastrium when the volunteer began to drink, to obtain the sonographic sections as early as possible. Images from the proximal stomach were obtained at $t = 0$, 5, 10, 15, 20, and 30 min, whereas images from the distal stomach were obtained at 10 min intervals from $t = 0$–90 min. The frequency of antral contractions was recorded over 5 min periods from $t = 5$–10 min, 30–35 min, 60–65 min, and 90–95 min. At 10 min intervals from $t = -10$ min to $t = 90$ min, sensations of bloating, fullness, abdominal discomfort, nausea, hunger, and desire to eat were assessed using validated 100 mm visual analog questionnaires [26]. At 120 min after meal ingestion, volunteers were free to leave the laboratory.

Ultrasonographic measurements

Measurements were performed with the volunteer seated in a comfortable chair, leaning slightly backward (about 100°), using a Toshiba SSA-340A CL ultrasound machine with a 3.5-MHz convex array probe (Toshiba, Tokyo, Japan).

Antral area and gastric half-emptying time

The transducer was positioned vertically to visualize the antrum in cross section, with the superior mesenteric vein and abdominal aorta in a longitudinal section. Antral area was measured between antral contractions, whereas volunteers suspended their breathing at the end of expiration using the built-in caliper and calculation software. Gastric half-emptying time was defined as the time when antral area decreased to half the maximum increase above baseline and was calculated by linear interpolation between time points [17,25].

Proximal gastric dimensions

A sagittal section was obtained and the proximal gastric area was outlined 7 cm caudally from the superior margin of the fundus along the long axis of the stomach. The transducer was then rotated 90° clockwise to obtain an oblique frontal section from which the maximum proximal gastric diameter was obtained [20–24].

Antral contractions

Antral contractions were examined in a vertical section, and were defined as a reduction of the antral area (difference between relaxed and contracted area) by more than half of the relaxed area ($\Delta A/A$) more than 50% [19].

Statistical analysis

The data for antral area, fundic area, and diameter, frequency of antral contractions, and gastrointestinal sensation scores were compared using two-way repeated measures analysis of variance, with treatment and time as factors (SuperANOVA version 1.11, Abacus Concepts Inc., Berkeley, California, USA). Gastric half-emptying time values were compared using Student's paired t test (Statview 5, SAS Institute, Cary, North Carolina, USA). Paired t tests were also used to compare sensation scores before and immediately after the meal ($t = -10$ vs. 0 min) within each study day. Linear regression analysis was used to examine relationships between gastrointestinal sensations and gastric ultrasonographic data (antral area, fundic area and diameter, and frequency of antral contractions) at $t = 30$ min. Results are shown as means ± standard error. P values < 0.05 were considered significant.

Results

All volunteers tolerated the study well and there were no adverse events.

Antral area and gastric emptying (Fig. 1)

Antral area declined more rapidly ($P < 0.001$), and the gastric half-emptying time was less for ginger (13.1 ± 1.1 min) than placebo (26.7 ± 3.1 min, $P < 0.01$).

Fundic area and diameter (Fig. 2)

Neither fundic area nor fundic diameter differed significantly between ginger and placebo.

Antral contractions (Fig. 3)

The frequency of antral contractions was higher after ginger than placebo ingestion ($P < 0.005$), with significant differences at each of the four time intervals.

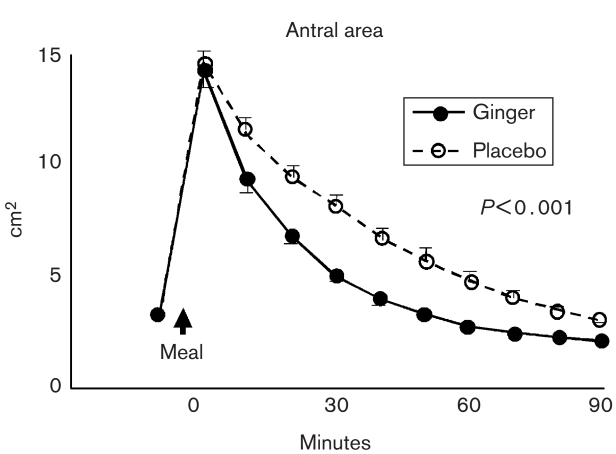
Gastrointestinal sensations (Fig. 4)

The meal was associated with an increase in fullness ($P < 0.05$ for ginger; $P < 0.005$ for placebo) and nausea ($P < 0.05$ for ginger; $P = 0.07$ for placebo), and a decrease in hunger ($P < 0.05$ for ginger and placebo) and desire to eat ($P < 0.05$ for ginger and placebo). There was no effect of the meal on bloating, whereas discomfort increased on the day of placebo ingestion ($P < 0.05$), but not on the day of ginger ingestion. No significant treatment effects on any sensation score were, however, observed. No linear relationships were evident between antral area and any gastrointestinal sensation when examined at 30 min after meal ingestion.

Discussion

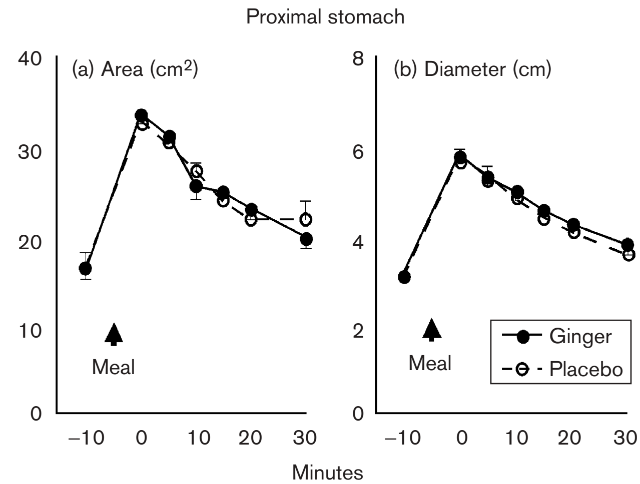
In this study, ginger markedly accelerated the gastric emptying of the soup meal, reduced postprandial antral area, and stimulated antral contractions when compared with placebo in healthy male volunteers. Dimensions of the proximal stomach were neither affected by ginger, nor was there a significant effect on postprandial gastrointestinal sensations.

Fig. 1



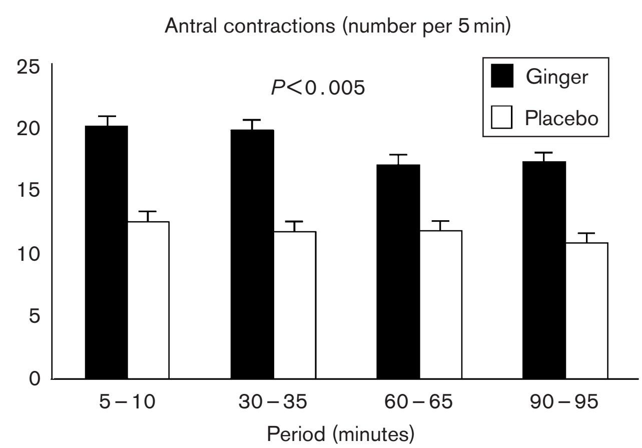
Antral area after consumption of the soup meal (between $t = -5$ and 0 min) following ginger (filled circles, solid line) or placebo ingestion (open circles, dashed line). Antral area declined more rapidly following ginger ingestion than placebo ingestion ($P < 0.001$). Data are means ± standard error, $n = 24$.

Fig. 2



(a) Proximal gastric area and (b) proximal gastric diameter after consumption of the soup meal following ginger (filled circles, solid line) or placebo ingestion (open circles, dashed line). No differences between ginger and placebo were observed. Data are means ± standard error, $n = 24$.

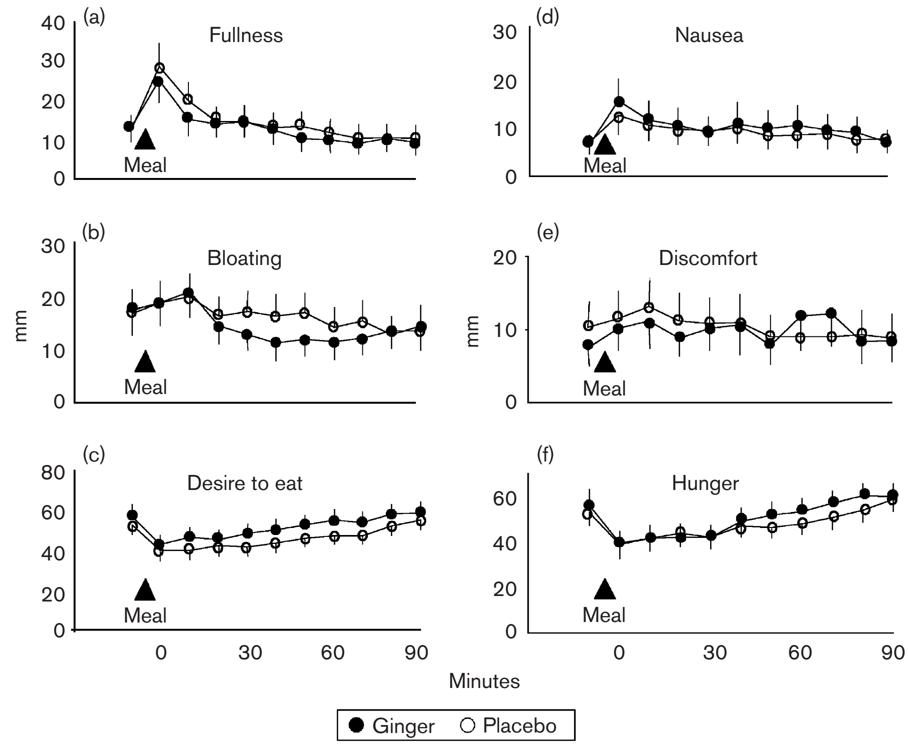
Fig. 3



Frequency of antral contractions (number per 5 min period) following the soup meal after ginger (filled bars) or placebo ingestion (open bars). The frequency of antral contractions was higher after ginger than starch ($P < 0.005$) ingestion. Data are means ± standard error, $n = 24$.

Our observation that ginger stimulates contractions of the antrum is consistent with the manometric study of Micklefield *et al.* [13]. Ours is, however, the first study to demonstrate an acceleration of gastric emptying by ginger in humans, but is consistent with the acceleration of gastric emptying observed in rodents [6,7]. Two earlier

Fig. 4



(a) Fullness, (b) Bloating, (c) Desire to eat, (d) Nausea, (e) Discomfort, and (f) Hunger scores from 100 mm visual analog scales after ginger (filled circles) or placebo ingestion (open circles). After the meal, there was an increase in fullness ($P < 0.05$ for ginger, $P < 0.005$ for placebo) and nausea ($P < 0.05$ and $P = 0.07$), a decrease in desire to eat and hunger (both $P < 0.05$ for ginger and placebo), but no effect on bloating. Discomfort increased on the placebo day ($P < 0.05$), but not the ginger day. No significant treatment effects on any sensation score were observed. Data are means ± standard error, $n = 24$.

studies that evaluated the effect of ginger on gastric emptying in humans were negative, but suffered from major limitations. Phillips *et al.* [14] used paracetamol in water to measure gastric emptying with no nutrient load, whereas Stewart *et al.* [15] used only 500 mg ginger and studied a relatively low nutrient load (75 kcal) in only eight volunteers. As the major factor regulating gastric emptying of a meal is feedback inhibition arising from the interaction of nutrients with the small intestine [16], it is important to use test meals with at least moderate energy content. It would be of interest to examine the effects of ginger on the rate of gastric emptying in patients with established gastroparesis.

We did not observe any effect of ginger on the area or diameter of the gastric fundus. This probably indicates that the more rapid reduction in antral area after the meal with ginger, when compared with placebo, does indeed reflect more rapid gastric emptying, rather than redistribution of gastric contents from the distal to the proximal region of the stomach. We, however, cannot exclude some redistribution to the gastric corpus without a change in the fundic area as we did not specifically image this region; more sophisticated techniques, such as three-dimensional ultrasound, single photon emission computed tomography, or magnetic resonance imaging would be needed to image the total gastric volume.

Drugs that accelerate gastric emptying have varying effects on the gastric fundus. For example, meal-induced fundic relaxation, which is often impaired in association with early satiety in patients with functional dyspepsia [27], is augmented by cisapride [28], whereas the most potent prokinetic drug, erythromycin, contracts the fundus after a meal [29]. Although ginger has been reported to induce contraction of rodent fundus *in vitro* [3], the effect *in vivo*, where innervation remains intact, might differ. Furthermore, the effects of ginger on smooth muscle appear to differ between gastrointestinal regions, and between species, whereas in some settings, ginger exhibits a smooth muscle relaxant effect [30]. In dogs, ginger is reported to induce contractions of the antrum, but not the body of the stomach [9].

The lack of any effect of ginger on gastrointestinal sensations in our study is not surprising, as the volunteers were healthy and did not suffer from any gastrointestinal symptoms. Moreover, the nutrient load was relatively low

($\sim$120 kcal), and the increases noted in fullness and nausea after meal ingestion were very modest. Similarly, the lack of a relationship between fullness and antral area, which had been noted in earlier studies [11,12], is probably accounted for by our low nutrient load – Jones *et al.* used $\sim$300 kcal [11] and Sturm *et al.* gave 250 and 750 kcal meals [12]. Indeed, Hveem *et al.* [17] reported a relationship between fullness and antral area for a high-nutrient (300 kcal) meal, but not for a low-nutrient (20 kcal) meal. Further study of the effects of ginger on antral area and gut sensations would be of interest in patients with diabetes mellitus or functional dyspepsia, as both these groups have an abnormally wide antrum postprandially [31].

We did not investigate the pharmacology of the active components of ginger; these include saponins, flavonoids, and alkaloids, some of which have cholinergic actions [3]. We administered ginger 1 h before the meal to allow sufficient time for absorption and systemic effects of the active compounds. Earlier investigators have employed a similar interval between dosing and evaluation of the effect [15].

In conclusion, we have shown that ginger stimulates antral contractions, reduces postprandial antral area, and accelerates gastric emptying when compared with placebo. If reproduced in patients with gastrointestinal symptoms, these effects would provide a plausible explanation for the benefits of ginger in this population.

Acknowledgements

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Conflict of interest: none declared.

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