

Gender difference in the gastric emptying measured by magnetogastrography using a semi-solid test meal

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Summary

Background/aims: evidence of gender-related differences in gastric emptying have been reported in the literature. Usually, those researches have focusing only with solid or liquid meal and invasive techniques. The objective of this study was to know the differences in the half time of gastric emptying and frequency of peristaltic contractions measured with magnetogastrography (MGG) on healthy subjects, using a semi-solid test meal. **Methods:** the study was carried out in 16 healthy subjects without gastrointestinal disease history, they were divided in two groups, 8 male and 8 female. A test meal composed by 250 ml of yogurt and 3 grs of magnetite (Fe_3O_4), was employed. **Results:** the gastric emptying half times were found to be 32.3 ± 10.8 and 36.0 ± 6.7 minutes, for men and women, respectively. Magnetogastrography modality presented in this study is a useful technique to measure the gastric emptying and the peristaltic contractions frequency. The studies were performed in healthy subjects without side effects. Using this technique a significant statistical difference ($p < 0.05$) on gastric emptying from healthy volunteers was obtained between men and women. **Conclusions:** a contribution of this study was to demonstrate the feasibility of magnetogastrography to analyze gender differences in the gastric emptying half time using a semi-solid test meal.

Key words: magnetogastrography, gastric emptying, peristaltic contractions, gender differences.

Diferencias de género en el vaciado gástrico medido por magnetogastrografía usando un alimento de prueba semisólido

Resumen

Introducción/objetivo: se ha reportado en la literatura evidencia de las diferencias relativas al género en el vaciado gástrico. Generalmente se ha enfocando la investigación sólo con alimento de prueba sólido o líquido y con técnicas invasivas. El objetivo de este estudio fue conocer las diferencias en el tiempo medio de vaciado gástrico y la frecuencia de las contracciones peristálticas medidas con magnetogastrografía (MGG) en sujetos sanos, usando un alimento de prueba semisólido. **Métodos:** el estudio fue realizado en 16 sujetos sanos sin historia de enfermedades gastrointestinales. Fueron divididos en dos grupos: 8 mujeres y 8 hombres. Se empleó un alimento de prueba compuesto por 250 ml de yogurt y 3 grs de magnetita (Fe_3O_4). **Resultados:** los tiempos medios de vaciado gástrico encontrados fueron de 32.3 ± 10.8 y 36.0 ± 6.7 minutos, para los hombres y mujeres, respectivamente. La modalidad de magnetogastrografía presentada en este estudio es una técnica útil para medir el vaciado gástrico y la frecuencia de contracciones peristálticas. Los estudios fueron realizados en sujetos sanos sin efectos secundarios. Usando esta técnica se obtuvo una diferencia estadística significativa ($p < 0.05$) en el vaciado gástrico entre hombres y mujeres sanos. **Conclusiones:** una contribución de este estudio fue demostrar la viabilidad de la magnetogastrografía para analizar las diferencias de género en el tiempo medio de vaciado gástrico usando un alimento de prueba semisólido.

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Palabras claves: *magnetogastrografía, vaciado gástrico, contracciones peristálticas, diferencias de género.*

Abbreviations:

MGG: *magnetogastrography.*

cpm: *contractions per minute.*

Magnetogastrography (MGG) technique consists in the recording of magnetic signals generated by the electrical activity of the myenteric nervous system.¹⁻³ The signal intensities generated by the gastrointestinal system are less than pT, for which a SQUID magnetometer must be used in order to directly record it. On the other hand, sometimes an oral contrast is used to enhance the electromagnetic activity.^{4,5}

Pro-kinetic efficiency and pharmacological effects of several medicaments are parameters measured through gastric emptying evaluation,⁶ furthermore the diagnostic of gastrointestinal diseases,⁷ like gastroparesis⁸ and functional dyspepsia.⁹ On the other hand, it is known that the female hormonal production affects both the gastric emptying half time and the transit time of the lumen content.¹⁰ Several techniques have been implemented in order to get information about the gastric emptying, some of them including real-time ultrasound scanning of the gastric antrum,^{11,12} radio labeled scintigraphy,¹³ and electrogastrography (EGG).¹⁴ In particular, radio scintigraphy is one of the most used and accepted techniques in the study and diagnostic of gastrointestinal (GI) diseases, and it is considered as the gold standard technique in clinical medicine. It was the first technique available in hospitals with reproducible results.¹⁵

On the other hand, the EGG technique is the most similar to the MGG. Nevertheless, the respiration and circulation artifacts, as also the lack of recording functional diseases, as dyspepsia and irritable colon syndrome, are some disadvantages of this technique.¹⁶⁻¹⁸

The MGG is a relatively novel, non-invasive technique, it has been used to carry out different gastric studies in healthy subjects.^{5,19-21} The MGG modality described in this paper has the advantage of being implemented in hospital areas without a magnetically shielding room; even so, it only demands a basic computing control and a non-expensive hardware.

Increasing evidence of gender-related differences in gastric emptying has been reported in the litera-

ture.²²⁻²⁵ In concordance with previous reports, women have a longer half-emptying time for solids as compared to men (86 ± 5 vs 52 ± 3 min, $p < 0.05$).²² The difference could not be explained by antral motility alone. Increased proximal retention and a lower terminal emptying rate in women are observations to be further investigated.²³ So far we know, it does not exist research about gender differences in gastric emptying with semi-solid test meal and non-invasive techniques, simultaneously.

The aim of this research is a comparative study of the gastric emptying, according to the gender, by using a semi-solid test meal and the MGG technique.

Material and methods

The MGG system used in this study is composed by a magnetic stimulator of two magnetization coils with 60 loops of wire of about 6 mm diameter, bounded in five layers of 12 loops on an aluminum base, which have 105 cm of diameter and are arranged in a Helmholtz configuration.

The coils were placed with their axes horizontally, and the whole system has movement in the three axes, x , y , and z , enough to sweep the whole stomach. Also, they were connected in parallel and were energized through a capacitor bank composed of six cylindrical capacitors, which were charged with a voltage of 220 V, and which discharge generated a current pulse and therefore a magnetic induction pulse higher than 32 mT in the central region of the system. The duration of the pulse is 17.3 ± 1.2 ms.

On the other hand, signals of the remnant magnetization into the stomach were detected in an unshielded environment using a fluxgate magnetometer model 539, from the Applied Physics Systems, with a digital 3 axes output, which can convert and transmit over its serial port all three magnetic field components at a rate of 250 samples/s. Their accuracy and noise level are $0.1 \mu\text{T}$ and 3 nT , respectively. The data acquisition was performed in LabVIEW 7.⁵

Subjects

Sixteen healthy subjects, without gastrointestinal disease history participated in this study, divided in two groups, 8 male and 8 female. The average ages of the volunteers were 29.7 ± 7.3 and 23.4 ± 6 years for men and women, respectively. Finally, the body mass index was less than 30 kg/m^2 in both cases.

In order to have a homogenous group of women, they were measured in the early follicular stage of their menstrual cycle. Also, after applying a *t*-student statistical analysis ($p < 0.05$), for paired samples, there were observed no differences for both the age and the body mass index, between women and men enrolled in this study. It is shown in Table 1.

Table 1. Socio-demographic characteristics of the volunteers. A *t*-student statistical analysis ($p < 0.05$) for paired samples was performed.

	Men	Women		
	Mean \pm SD	Mean \pm SD	<i>t</i>	<i>p</i>
Age (years)	29.7 \pm 7.3	23.4 \pm 6	-1.90767	0.08
Body mass index (Kg/m ²)	28.5 \pm 3.2	27.2 \pm 2.2	-0.91071	0.38

Protocol

The protocol of this research was approved by the bioethics committee of the University of Guanajuato and it was according to the Agreement of Helsinki for studies in human beings. On the other hand, all subjects enrolled in the study gave their informed consent.

Each volunteer swallowed a semi-solid test meal and underwent a magnetic field pulse of 32 mT, in 17 ms. The whole experiment lasted around 90 minutes. Subjects attended the experiment with 12 hours of fasting. They ingested the oral contrast agent, which was composed with a mixture of 250 ml yogurt and 3 g of magnetite (Fe_3O_4). The magnetite particles size was from 75 to 125 μm , which guarantees that the particles will not be absorbed by the cells on the small bowel's microvillus. Furthermore, they are innocuous for the GI system, so they are eliminated in an average time of 50 h. All volunteers were in prone position during the experiment and underwent a magnetic field pulse each 15 minutes.

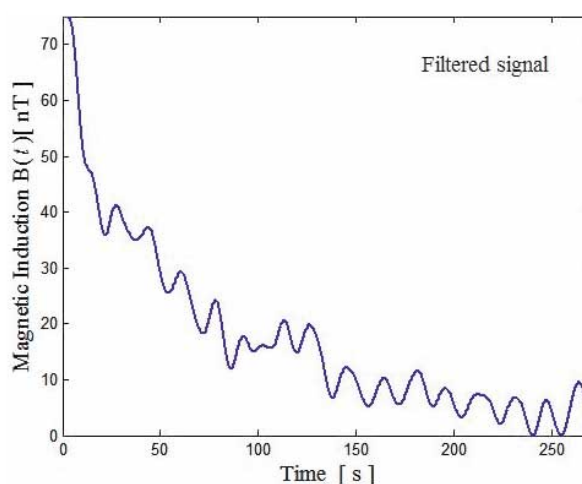
Data collection and digital signal processing

Each of the evaluated subjects underwent similar measurements section, which technical details are described as follow: all data acquisition was performed in LabVIEW computational environment. First, data in temporal domain were acquired during 5 min, with an electronic system (fluxgate magnetometer) at a rate of 30 samples/sec. Processing above was repeated seven times, each ten min, so

that, measurement sections late 105 min. The magnetometer fluxgate was held around 2 cm from abdominal surface on the left (about 3 cm) of xiphoid process.

Numerical analysis was carried out in MATLAB® 6.5, (1984-2002), (Math Works, Inc, Matick, Massachusetts, USA), where a routine was implemented in order to get a graph from each measurement, then, the first 10 point were averaged from each of the seven recordings recorded in each subject. The routine implemented also include two part of filtered. One for pass-band filtered (butterworth), cut off frequency of 25/60 Hz, in order to have the behavior of the signal in each whole measurement, see Figure 1. As long as, the second was a pass band filter (butterworth), from 2 to 25 cpm which was used to perform the Fourier transform from each record and used to identify the dominant peristaltic frequency and also the respiration frequency.

Figure 1. A typical spectrum, as obtained in this study (filtered). The time variation of the magnetic induction is shown during the 5 minutes of a data acquisition session.



Results

Figure 1 shows the filtered signal of one subjects, over there is possible to identify *a priori*, the gastric contractions number from each record. While, in Figure 2, signal spectral density of power is showed, where peristaltic frequency is quantified, in this measurement the dominant frequency was 3.48 cpm as long as the respiration frequency was almost 15 cpm. On the other hand, Figure 3 shows the gas-

Figure 2. Frequency domain spectrum from a typical measurement, in one subject. A band-pass Butterworth filter from 2 to 25 cpm was applied in order to clearly observe both the peristaltic and respiration frequencies, respectively.

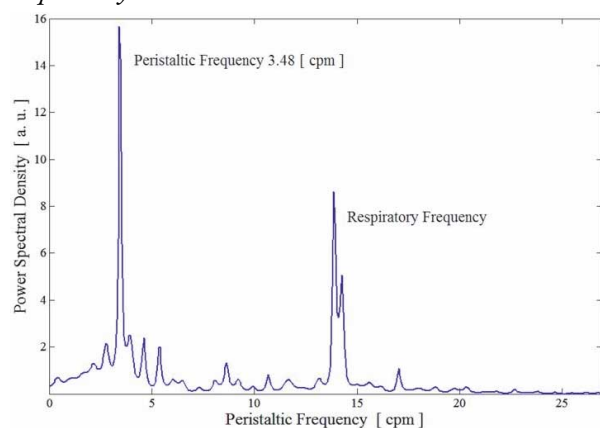
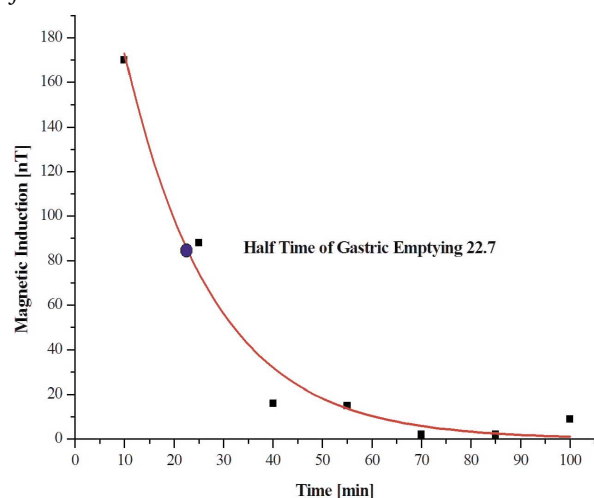


Figure 3. Experimental data for one subject (dots). The solid line is the fitting of a first order exponential function.



tric emptying estimation. Each point is the average of the first 10 points recorded in the magnetic intensity of the seven registers performed in each subject measurement. Then a exponential first order fit available in Origin-Lab 6.5 software was applied, in this fitting line the gastric emptying half time was localized, which one is 22.7 min for this subject.

In order to find statistical significance from gastric emptying between men and women, t student test was carried out and it was obtained significance difference with ($p < 0.05$) this is showed in Figure 4,

furthermore, gastric emptying is also showed, these are $t_{1/2} = 32.3 \pm 10.8$ min and $t_{1/2} = 32.3 \pm 10.8$ for men and women, respectively.

Finally, the t student test was also applied to the peristaltic frequency recorded in the same study; in this case there is not significance difference, Figure 5, where the dominant frequencies are $f = 2.97 \pm 0.47$ cpm and $f = 2.94 \pm 0.37$ cpm for men and women, respectively.

Figure 4. A comparison of the gastric emptying half time, between genders, by using a t student statistical analysis. A statistically significant difference was obtained.

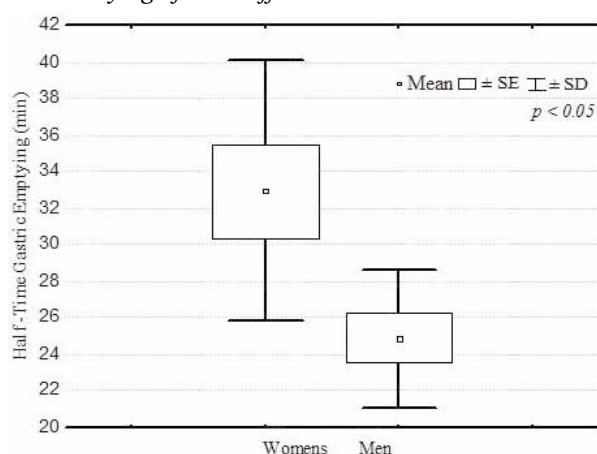
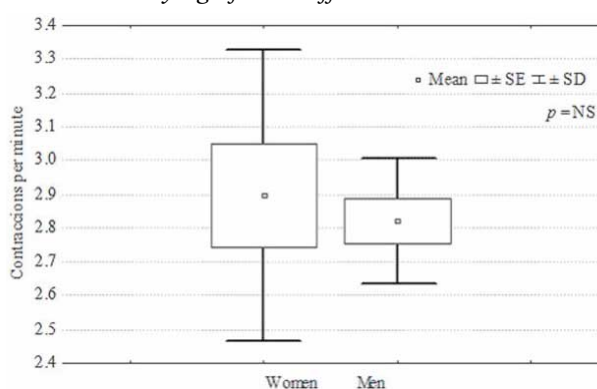


Figure 5. A comparison of the peristaltic frequencies between genders, by using a t student statistical analysis. Not statistically significant differences were observed.



Discussion

The findings of our research, by using a biomagnetic method of measurement, agree with previous results reported in the literature by other techniques.^{4,11,25,26} Such reports have found differences in

the time of gastric emptying between men and women. Moreover, most of the studies analyzing the difference between the gastric emptying in men and women have commonly used a solid test meal.²⁵ A contribution of this study was to demonstrate the feasibility to analyze the gastric emptying half time with a semi-solid test meal, reducing the time of measurement. Our results are also in good agreement with those reported by Porkka *et al.*,²⁷ who found a $t_{1/2} = 31.3 \pm 8.2$ minutes for yogurt, measured by using scintigraphy.

On the other hand, several studies have been performed to validate the MGG methodology. Americo *et al* have published a scintigraphic validation of AC biosusceptometry to study gastric activity, in particular, they found a similar distal accumulation time in both techniques.²⁸ Also De la Roca *et al* evaluated the half-time gastric emptying reproducibility measured by MGG. The reproducibility estimation was above 85%. Thus the MGG technique demonstrated to have capacity to measure the gastric emptying.²⁹ However, more detail comparisons of the MGG with other techniques are required.

Finally, we have to emphasize that the results obtained with the Fast Fourier transformed data, show an amplitude in the standard deviations that agrees with studies indicating the possibility of disorders or dysrhythmies in the gastric myoelectric activity,^{8,30} which can be influenced for environmental or emotional conditions. These factors can accelerate or slow down the frequency of contractions. However, other gender differences could be considered to explain the results, for instance, variability in the force or intensity in the contractions that can influence the gastric emptying time.

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