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The Impact of Age, Sex, Body Mass Index and Menstrual Cycle Phase on Gastric Myoelectrical Activity Characteristics in a Healthy Croatian Population

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A B S T R A C T

The aim of the study was to determine the impact of demographic and anthropometric parameters on the gastric myoelectrical activity characteristics in a healthy Croatian population. The influence of age, sex, body mass index (BMI) and menstrual cycle phase on the gastric myoelectrical activity characteristics was assessed. The study included 120 healthy subjects of both sexes (60 male and 60 female), divided into four age groups (18–35, 36–50, 51–65 and >65 years) and three BMI groups (BMI <25, 25–30 and >30). Female subjects of reproductive age were divided into three groups according to menstrual cycle phase (day 1–3, day 4–8 and day 9–20 of menstruation). All study subjects underwent percutaneous electrogastrography (EGG) for 60 min before and 60 min after a test meal. The following parameters of the gastric myoelectrical activity were observed: dominant frequency (DF); dominant frequency within normal range (DFNR, %); coefficient of variation for dominant frequency (CVDF); dominant strength (DS. mV); postprandial increase intensity in dominant strength (PPIIDS, %); bradygastria (BG, c/min, %); tachygastria (TG, c/min, %); and arrhythmia (AR). Age was found to influence preprandial but not postprandial DFNR, CVDF and AR. Sex influenced preprandial DF, CVDF, DS and BG, and postprandial DF, CVDF, PPIIDS and TG. BMI exerted an impact on preprandial TG and AR, and postprandial DF, CVDF and AR. The phase of menstrual cycle influenced DF in preprandial period and none of EGG parameters in postprandial period.

***Key words**: gastric myoelectrical activity, electrogastrography, sex, body mass index, menstrual cycle*

Introduction

Stomach is a neuromuscular organ the task of which is to adapt to the food taken at particular meals, to mince it and to empty the minced content to the duodenum. The mincing and emptying of the gastric content are the result of a complex myoelectrical activity based on slow waves[1]. These are triphasic, rhythmical depolarization and repolarization waves formed in Cajal cells located on the greater curvature, at the junction of the proximal and distal portion of the stomach. Slow waves expand distally from Cajal cells to the antrum, at a regular rhythm of 3 cycles per minute (cpm) on an average[2]. The slow waves themselves cause mild contractions of the circular muscular layer. Strong contractions that are needed for the gastric content mixing and emptying are formed consequentially to action potential peaks occurring during the slow wave plateau phase. The relation-ship of action potential peaks with slow waves makes the electrophysiological basis of gastric peristalsis. Slow waves determine the frequency of gastric contractions as well as the direction and rate of peristaltic wave expansion. These myoelectrical activities along with neurohumoral stimulation result in coordinated muscular contraction and relaxation, known as gastric motility[3,4]. Numerous factors influence gastric myoelectrical activity, e.g., starvation, postprandial state, neurohumoral status, stress, etc. Gastrin, cholecystokinin and acetylcholine stimulate gastric contractility, whereas norepinephrine, neurotensin, prostaglandin E2 and vasoactive intestinal polypeptide have an opposite effect[3].

Percutaneous electrogastrography (EGG) is a novel method to measure gastric myoelectrical activity by use of skin electrodes applied onto the abdominal skin. It is a functional method which is noninvasive, painless, and can be safely used in adults, children and pregnant women[5–7]. Studies have shown good correlation between EGG recordings obtained by leads attached to gastric serosa and those applied onto abdominal skin[8,9]. The following types of activity can be identified according to the gastric myoelectrical activity frequency thus recorded: bradygastria (0.5–2.0 cpm), normogastria (2.0–4.0 cpm), tachygastria (4.0–9.0 cpm) and duodenal-respiratory rhythm (9.0–15.0 cpm)[7].

The aim of the present study was to determine the effect of various factors on the gastric myoelectrical activity in healthy subjects. The impact of age, sex, menstrual cycle phase and body mass index (BMI) on the gastric myoelectrical activity characteristics was assessed in a group of healthy volunteers from the Croatian general population, in order to help introduce the method in practical use to study various clinical disorders.

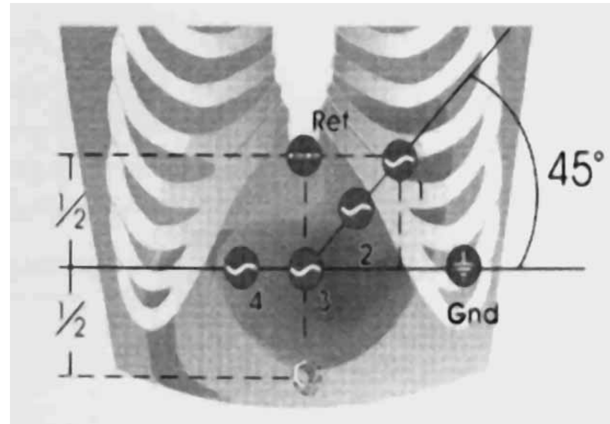

Fig. 1. Positioning of EGG leads. Ref – reference lead, Gnd – ground lead.

Subjects and Methods

Subjects

The study included 120 healthy volunteers of different age, sex, BMI, and in women of different generative age and menstrual cycle phase. Subjects were divided according to sex (60 male and 60 female) into four age groups (18–35, 36–50, 51–65 and >65 years) of 30 subjects (15 male and 15 female). Female subjects of reproductive age were divided into three groups according to menstrual cycle phase (day 1–3, day 4–8 and day 9–20 of menstruation). According to BMI, study subjects were divided into three groups (BMI<25, 25–30 and >30). The subjects were thoroughly informed on the study and an informed consent in writing was obtained prior to enrolment in the study.

Study protocol

Gastric myoelectrical activity was determined by percutaneous EGG on a Medtronic Polygram ID six-channel instrument by use of Medtronic EGG leads placed onto the prepared upper abdominal skin. The preparation of the skin was essential for quality of the recordings. Abrasive gel was first rubbed to entire electrode site on the skin with gauze pad. Excess of gel was rubbed with clean gauze pad. Then electrode gel was administered to the skin and electrode, and remains were removed with water. In all subjects, the leads were first placed according to anatomic guidelines listed in the relevant literature, so as to form a bipolar electrical pair in order to record

TABLE 1
GENERAL CHARACTERISTICS OF STUDY SUBJECTS

		No. of subjects (n)	Mean age (yrs) (χ± SD)	Body mass index (χ± SD)
Age (yrs)	18–35	30	25.29±4.39	20.44±2.7
	36–50	30	44.47±4.19	27.15±4.6
	51–65	30	57.91±4.78	27.57±4.5
	>65	30	70.09±3.14	26.98±1.7
Sex	Female	60	46.11±18.37	24.82±5.0
	Male	60	51.26±13.57	26.67±3.5
Body mass index	<25	42	37.76±16.00	21.63±2.5
	25–30	46	58.47±12.77	27.55±1.6
	>30	32	53.43±10.47	32.77±3.6
Menstrual cycle phase (day)	1–3	15	31.57±10.45	20.68±3.2
	4–8	17	31.17±8.40	22.27±2.8
	9–20	20	27.6±10.36	23.01±8.1

electrical activity under the surface (the lead at the medial line between the umbilicus and xiphoid was placed first; second lead was placed at 4–6 cm to the right in the same plane; third lead was placed at 4–6 cm to the left, at a 45° angle to the first lead; fourth lead was placed at 4–6 cm above the third one, at a 45° angle; reference lead was placed below the xiphoid process; and ground lead was placed at 10 cm from the first lead) and then across the antrum which was positioned by ultrasound (Figure 1). The subjects were fasting, in supine position, with the head lifted by 45°. As many medications influence gastric myoelectrical activity, the subjects were asked to take no drugs for 48 h before the study[6–10]. Data were analyzed by visual inspection and computer processing. The test consisted of two parts: preprandial measurement performed for 60 min before, and postprandial measurement performed for 60 min after a test meal. Test meal was prepared in hospital kitchen under a dietitian's supervision, and consisted of a sandwich and 120 mL of orange juice. Total calorie value of the meal was 475 kcal, weight 170 g, and fat to protein to carbohydrate ratio was 17%:21%:61%[11,12].

The impact of age, sex, BMI and menstrual cycle phase on the following parameters of gastric myoelectrical activity was observed: dominant frequency (DF, c/min); DF percentage within normal range (DFNR, %); coefficient of variation for dominant frequency (CVDF); dominant strength (DS, mV); postprandial increase intensity in dominant strength (PPIIDS; %); bradygastria (c/min, %); tachygastria (c/min, %); and frequency of duodenal-respiratory range (c/min, %).

Statistics

Standard methods of descriptive statistics were employed on statistical analysis. Results of quantitative measurements were expressed as mean and standard deviation for study groups. Qualitative data were expressed as frequency and percentage. Between-group differences were tested by statistical methods as follows: Pearson χ^2-test for differences in the prevalence of normogastria, bradygastria, tachygastria and duodenal-respiratory frequency according to age, sex, BMI, and menstrual cycle phase in female subjects; t-test for differences in DF, CVDF and DS according to sex and time of measurement; analysis of variance for these variables according to age, BMI, and menstrual cycle phase in female subjects; multivariate analysis of the effect of particular variables on the normal gastric electrical activity; and logistic regression analysis to determine the risk of gastric motility impairment with particular variable combinations.

Results

General characteristics of the study groups are presented in Table 1. The study included an equal number of male and female subjects (60 each). Of 60 female subjects, 52 were of generative age. The mean age was 51.26 and 46.11 years, and mean BMI 26.67 and 24.82 in male and female subjects, respectively.

Effect of age on gastric myoelectrical activity parameters

Preprandial measurement of gastric myoelectrical activity showed statistically significant differences in DFNR, CVDF and rate of AR according to age groups, whereas no such difference for any of the gastric myoelectrical activity parameters was recorded on postprandial measurement (Table 2). Comparison of preprandial

TABLE 2
EFFECT OF AGE ON PREPRANDIAL AND POSTPRANDIAL CHARACTERISTICS OF GASTRIC MYOELECTRICAL ACTIVITY IN STUDY SUBJECTS

	PreP					PostP				
	18–35 yrs	36–50 yrs	51–65 yrs	>65 yrs	p	18–35 yrs	36–50 yrs	51–56 yrs	>65 yrs	p
Subjects (n)	30	30	30	30		30	30	30	30	
Mean age (yrs)	25.29±4.39	44.5±4.19	57.91±4.78	70.1±3.14	0.000	25.29±4.39	44.5±4.19	57.91±4.78	70.1±3.14	0.000
BMI	20.44±2.66	27.2±4.63	27.57±4.45	27±1.73	0.185	20.44±2.66	27.2±4.63	27.57±4.45	27±1.73	0.185
DF (c/min)	2.84±0.23	2.87±0.24	2.79±0.36	3.08±0.36	0.094	2.82±0.41	3.06±0.21	3.04±0.32	3±0.47	0.179
DFNR (%)	78.11±16.45	84.4±12.77	74.24±17.2	92.1±9.39	0.006	88.63±8.56	90.1±11.16	83.33±13.08	87.9±15.7	0.586
CVDF	0.29±0.12	0.36±0.34	0.48±0.35	0.14±0.14	0.006	0.27±0.17	0.19±0.11	0.26±0.1	0.2±0.11	0.032
DS (mV)	47.89±5.31	46.8±3.47	45.83±4.85	48.6±4.3	0.177	51.18±3.3	51.6±4.23	50.77±3.8	52±4.58	0.368
PPIIDS (%)						8.09±11.5	10.6±9.19	11.88±14.53	7.56±11.4	0.321
BG(%)	4.34±5.01	3.75±3.59	3.74±3.02	1.13±2.52	0.170	3.33±4.23	2.67±3.89	3.85±3.42	4.47±5.34	0.315
TG (%)	5.93±5.78	3.38±3.39	5.65±5.02	2.57±4.52	0.740	3.28±2.74	2.51±3.73	4.54±5.25	3.94±8.3	0.781
AR (%)	11.65±10.81	8.49±7.27	16.38±13.17	4.18±5.3	0.011	4.74±4.92	4.73±4.78	8.47±9.13	3.75±5.77	0.277

PreP – preprandial, PostP – postprandial, BMI – body mass index, DF – dominant frequency, DFNR – dominant frequency within normal range, CVDF – coefficient of variation for dominant frequency, DS – dominant strength, PPIIDS – postprandial increase intensity in dominant strength, BG – bradygastria, TG – tachygastria, AR – arrhythmia

and postprandial results of the gastric myoelectrical activity parameters revealed a statistically significantly higher rate of DFNR and thus lower rate of AR in the 18–35 age group. Postprandial DS was statistically significantly higher. In the 36–50 and 51–65 age groups, DF and DS were statistically significantly higher in the postprandial period, whereas other parameters showed no statistically significant differences. In the ≥65 age group, DS was statistically significantly higher in the postprandial period, whereas other parameters yielded no statistically significant differences (Table 3).

Effect of sex on gastric myoelectrical activity parameters

Comparison of preprandial gastric myoelectrical activity parameters according to sex showed a statistically significant difference in DF and DS, which were higher in women, whereas CVDF was higher in men. A statisti-

TABLE 3
COMPARISON OF PREPRANDIAL AND POSTPRANDIAL CHARACTERISTICS OF GASTRIC MYOELECTRICAL ACTIVITY IN STUDY SUBJECTS ACCORDING TO AGE GROUPS

	Age group (yrs)											
	18–35			36–50			51–65			>65		
	PreP	PostP	p	PreP	PostP	p	PreP	PostP	p	PreP	PostP	p
Subjects (n)	30	30		30	30		30	30		30	30	
Mean age (yrs)	25.29±4.4	25.3±4.4	1.000	44.5±4.19	44.5±4.19	1.000	57.91±4.8	57.9±4.8	1.000	70.1±3.14	70.1±3.14	1.000
BMI	20.44±2.7	20.4±2.7	1.000	27.2±4.63	27.2±4.63	1.000	27.57±4.5	27.6±4.5	1.000	27±1.73	27±1.73	1.000
DF (c/min)	2.84±0.2	2.82±0.4	0.846	2.87±0.24	3.06±0.21	0.018	2.79±0.4	3.04±0.3	0.045	3.08±0.36	3±0.47	0.611
DFNR (%)	78.11±16	88.6±8.6	0.035	84.4±12.77	90.1±11.2	0.193	74.24±17	83.3±13	0.196	92.1±9.39	87.9±15.7	0.608
CVDF	0.29±0.1	0.27±0.2	0.800	0.36±0.34	0.19±0.11	0.091	0.48±0.4	0.26±0.1	0.072	0.14±0.14	0.2±0.11	0.298
DS (mV)	47.89±5.3	51.2±3.3	0.022	46.8±3.47	51.6±4.23	0.000	45.83±4.9	50.8±3.8	0.011	48.6±4.3	52±4.58	0.044
BG (%)	4.34±5	3.33±4.2	0.560	3.75±3.59	2.67±3.89	0.592	3.74±3	3.85±3.4	0.902	1.13±2.52	4.47±5.34	0.051
TG (%)	5.93±5.8	3.28±2.7	0.157	3.38±3.39	2.51±3.73	0.509	5.65±5	4.54±5.3	0.560	2.57±4.52	3.94±8.3	0.570
AR (%)	11.65±11	4.74±4.9	0.022	8.49±7.27	4.73±4.78	0.102	16.38±13	8.47±9.1	0.111	4.18±5.3	3.75±5.77	0.815

PreP – preprandial, PostP – postprandial, BMI – body mass index, DF – dominant frequency, DFNR – dominant frequency within normal range, CVDF – coefficient of variation for dominant frequency, DS – dominant strength, PPIIDS – postprandial increase intensity in dominant strength, BG – bradygastria, TG – tachygastria, AR – arrhythmia

TABLE 4
EFFECT OF SEX ON PREPRANDIAL AND POSTPRANDIAL CHARACTERISTICS OF GASTRIC MYOELECTRICAL ACTIVITY IN STUDY SUBJECTS

	PreP			PostP		
	Female	Male	p	Female	Male	p
Subjects (n)	60	60		60	60	
Mean age (yrs)	46.11±18.37	51.3±13.57	0.125	46.11±18.37	51.3±13.57	0.125
BMI	24.82±5.03	26.7±3.47	0.067	24.82±5.03	26.7±3.47	0.067
DF (c/min)	2.91±0.32	2.84±0.26	0.014	2.99±0.39	2.96±0.31	0.019
DFNR (%)	84.65±14.15	76.1±16.77	0.264	88.04±11.4	87.1±13.7	0.791
CVDF	0.26±0.17	0.45±0.42	0.049	0.23±0.14	0.23±0.11	0.032
DS (mV)	48.09±4.27	45.4±4.48	0.039	51.37±3.88	51.5±4.05	0.529
PPIIDS (%)				7.39±8.98	14.6±14.74	0.023
BG (%)	2.99±3.94	4.2±3.53	0.032	3.31±3.89	3.94±4.88	0.615
TG (%)	4.27±4.96	4.71±4.56	0.075	3.46±5.49	3.05±4.01	0.007
AR (%)	8.11±8.89	15±11.65	0.625	5.07±6.36	5.96±6.11	0.120

PreP – preprandial, PostP – postprandial, BMI – body mass index, DF – dominant frequency, DFNR – dominant frequency within normal range, CVDF – coefficient of variation for dominant frequency, DS – dominant strength, PPIIDS – postprandial increase intensity in dominant strength, BG – bradygastria, TG – tachygastria, AR – arrhythmia

cally significant difference was also recorded for BG with a higher rate in men. In the postprandial period, statistically significant sex differences were found in DF, CVDF, PPIIDS and rate of TG (Table 4). Comparison of preprandial and postprandial EGG characteristics according to sex yielded a statistically significant difference in DS, which was higher in the postprandial period, along with a significantly reduced rate of AR (Table 5).

Effect of body mass index on gastric myoelectrical activity parameters

Statistically significant differences according to BMI were found in the preprandial rate of TG and AR, and in postprandial DV, CVDF and rate of AR (Table 6). Comparison of the impact of BMI on preprandial and postprandial gastric myoelectrical activity yielded statistically significant differences in postprandial DF, DFNR, DS (increase) and rate of AR (decrease) in the BMI<25 group. In the BMI 25–30 group, a statistically significant difference was only recorded in postprandial DS (increase), and in the BMI>30 group only in postprandial DF (increase), whereas other gastric myoelectrical activity parameters showed no such differences (Table 7).

Effect of menstrual cycle on gastric myoelectrical activity parameters

Preprandial measurements showed a statistically significant difference only in DF, whereas postprandial measurements yielded no statistically significant difference in any of the study parameters of the gastric myoelectrical activity (Table 8). Comparison of preprandial and postprandial characteristics of the gastric myoelectrical activity according to menstrual cycle phase showed a statistically significant postprandial increase only in DS in the first group of women (menstrual cycle day 1–3), whereas other groups showed no such difference in any of the study parameters (Table 9)

Discussion

The results of our study that included a large group of the healthy Croatian population and employed the sophisticated multi-channel electrogastrograph, clearly indicated the impact of age, sex and BMI, and a minor impact of menstrual cycle phase on the gastric myoelectrical activity. Therefore, these demographic and anthropometric parameters should be taken in consideration on interpretation of EGG findings.

The development of percutaneous EGG as a simple and noninvasive method of gastric myoelectrical activity measurement has enabled the study of electrophysiological events underlying gastric motility[5,6]. There are only few studies of gastric myoelectrical activity in healthy individuals, mostly in a small number of subjects. Literature reports provide different data on the effect of age, sex, BMI and menstrual cycle phase on gastric myoelectrical activity. Real Martinez et al.[13] report that sex had no effect, while age and BMI had an effect on gastric myoelectrical activity, whereas Parkman et al.[14] report on changes in the gastric myoelectrical activity with age, sex and menstrual cycle phase. Phaffenbach et al.[15] found that age and sex had no effect on the majority of EGG parameters, with the only exception of CVDF. In their multi-center study, Simonian et al.[16] found age and sex to exert no impact on gastric myoelectrical activity, while BMI and ethnicity influenced the parameters of gastric myoelectrical activity. An overview of the various studies shows the impact of age and sex on the parameters of gastric myoelectrical activity to vary from evident association through minor effects to the clear lack of association. Besides sex differences in the parameters of

TABLE 5
COMPARISON OF PREPRANDIAL AND POSTPRANDIAL CHARACTERISTICS OF GASTRIC MYOELECTRICAL ACTIVITY IN STUDY SUBJECTS ACCORDING TO SEX

	Women			Men		
	PreP	PostP	p	PreP	PostP	p
Subjects (n)	60	60		60	60	
Mean age (yrs)	46.11±18.37	46.11±18.37	1.000	51.3±13.57	51.3±13.57	1.000
BMI	24.82±5.03	24.82±5.03	1.000	26.7±3.47	26.7±3.47	1.000
DF (c/min)	2.91±0.32	2.99±0.39	0.285	2.84±0.25	2.96±0.3	0.192
DFNR (%)	84.65±14.15	88.04±11.4	0.175	76.08±16.21	87.05±13.24	0.102
CVDF	0.26±0.17	0.23±0.14	0.594	0.45±0.41	0.24±0.11	0.075
DS (mV)	48.09±4.27	51.37±3.88	0.000	45.35±4.33	51.47±3.91	0.001
BG (%)	2.99±3.94	3.31±3.89	0.677	4.2±3.42	3.94±3.52	0.853
TG (%)	4.27±4.96	3.46±5.49	0.510	4.71±4.41	3.05±3.42	0.651
AR (%)	8.11±8.89	5.07±6.36	0.037	14.99±11.25	5.95±5.91	0.024

PreP – preprandial, PostP – postprandial, BMI – body mass index, DF – dominant frequency, DFNR – dominant frequency within normal range, CVDF – coefficient of variation for dominant frequency, DS – dominant strength, PPIIDS – postprandial increase intensity in dominant strength, BG – bradygastria, TG – tachygastria, AR – arrhythmia

TABLE 6
EFFECT OF BODY MASS INDEX (BMI) ON PREPRANDIAL AND POSTPRANDIAL CHARACTERISTICS OF GASTRIC MYOELECTRICAL ACTIVITY IN STUDY SUBJECT

	Pre PBMI				Post PBMI			
	<25	25–30	>30	p	<25	25–30	>30	p
Subjects (n)	42	46	32		42	46	32	
Mean age (yrs)	37.76±4.39	58.47±12.77	53.43±10.7	0.020	37.76±4.39	58.47±12.77	53.43±10.74	0.020
BMI	21.63±2.66	27.55±1.56	32.77±3.57	0.050	21.63±2.66	27.55±1.49	33.53±3.57	0.000
DF (c/min)	2.86±0.32	2.93±0.24	2.93±0.4	0.753	3.03±0.39	2.86±0.27	3.23±0.27	0.001
DFNR (%)	73.36±14.5	84.27±15.94	86.23±16.9	0.556	88.67±11.01	85.93±12.92	89.97±11.68	0.317
CVDF	0.34±0.27	0.27±0.22	0.37±0.46	0.602	0.24±0.15	0.23±0.11	0.17±0.08	0.002
DS (mV)	47.39±4.64	46.8±4.42	48.03±4.49	0.131	51.53±3.38	51.13±4.16	51.75±4.73	0.923
PPIIDS (%)					9.55±11.42	9.3±11.27	10.21±13.11	0.758
BG (%)	4±4.01	2.54±3.28	3.17±4.67	0.609	3.2±4.29	4.13±3.92	2.6±4.14	0.251
TG (%)	5.51±5.21	3.02±4.28	4.16±4.17	0.006	4.12±6.28	2.44±2.74	4.18±5.06	0.081
AR (%)	11.14±10.48	10.16±10.49	6.46±8.47	0.038	4.01±4.14	7.6±8.07	3.25±3.18	0.002

PreP – preprandial, PostP – postprandial, BMI – body mass index, DF – dominant frequency, DFNR – dominant frequency within normal range, CVDF – coefficient of variation for dominant frequency, DS – dominant strength, PPIIDS – postprandial increase intensity in dominant strength, BG – bradygastria, TG – tachygastria, AR – arrhythmia

TABLE 7
COMPARISON OF PREPRANDIAL AND POSTPRANDIAL CHARACTERISTICS OF GASTRIC MYOELECTRICAL ACTIVITY IN STUDY SUBJECTS ACCORDING TO BODY MASS INDEX

	BMI<25			BMI 25–30			BMI>30		
	PreP	PostP	p	PreP	PosP	p	PreP	PostP	p
Subjects (n)	42	42		46	46		32	32	
Mean age (yrs)	37.76±4.39	37.76±4.39	1.000	58.47±12.77	58.47±12.8	1.000	53.43±10.74	53.43±10.7	1.000
BMI	21.63±2.66	21.63±2.66	1.000	27.55±1.56	27.55±1.56	1.000	32.77±3.57	32.77±3.57	1.000
DF (c/min)	2.86±0.32	3.03±0.39	0.033	2.93±0.24	2.82±0.27	0.302	2.93±0.4	3.23±0.27	0.017
DFNR (%)	79.36±14.5	88.67±11	0.012	84.27±15.94	85.18±13.2	0.784	86.23±16.85	91.4±12.3	0.588
CVDF	0.34±0.27	0.24±0.15	0.125	0.27±0.22	0.24±0.11	0.643	0.37±0.46	0.16±0.08	0.263
DS (mV)	47.39±4.64	51.53±3.38	0.000	46.8±4.42	50.76±4.1	0.001	48.03±4.49	52.64±5.29	0.118
BG (%)	4±4.01	3.2±4.29	0.604	2.54±3.28	4.35±4.01	0.136	3.17±4.67	2.23±4.25	0.707
TG (%)	5.51±5.21	4.12±6.28	0.290	3.02±4.28	2.57±2.83	0.694	4.16±4.17	3.59±5.3	0.801
AR (%)	11.14±10.48	4.01±4.14	0.002	10.16±10.49	8±8.31	0.625	6.46±8.47	2.78±3.4	0.574

PreP – preprandial, PostP – postprandial, BMI – body mass index, DF – dominant frequency, DFNR – dominant frequency within normal range, CVDF – coefficient of variation for dominant frequency, DS – dominant strength, PPIIDS – postprandial increase intensity in dominant strength, BG – bradygastria, TG – tachygastria, AR – arrhythmia

gastric myoelectrical activity, some studies point to the effect of menstrual cycle phase, i.e. difference according to the onset, midpoint or termination of the menstrual cycle in women of reproductive age[13,14]. The lack of uniformity on defining study groups according to menstrual cycle phase should be noted on result comparison. In the study by Parkman et al.[14], premenopausal women were divided into menstrual cycle day 1–3, day 8–10 and day 18–20 groups, and showed a postprandial increase in DF in the first two groups, which was not found in our study, the inconsistency being probably due to differences in the subject group definition. The effect of menstrual cycle phase on gastric emptying has also been studied. So, Knight *et al.*[17] found the rate of gastric emptying to be slower in young women than in age-matched men, which was explained by the altered motor function of the distal segment of the stomach. Bennink *et al.*[18] also report on the solid food emptying to be slower in women than in men. In contrast to these studies, Mones *et al.*[19] found that menstrual cycle had no impact on gastric emptying. There is a clear effect of BMI on gastric myoelectrical activity characteristics. A decline in the value of signal amplitude has been described in obese individuals and explained by the greater stomach distance from the ab-

TABLE 8
EFFECT OF MENSTRUAL CYCLE ON PREPRANDIAL AND POSTPRANDIAL CHARACTERISTICS OF GASTRIC MYOELECTRICAL ACTIVITY IN STUDY WOMEN

	PreP Phase of menstrual cycle				PostP Phase of menstrual cycle			
	Day 1–3	Day 4–8	Day 9–20	p	Day 1–3	Day 4–8	Day 9–20	p
Subjects (n)	15	17	20		15	17	20	
Mean age (yrs)	31.57±10.54	31.2±8.4	27.6±10.4	0.578	31.57±10.45	31.2±8.4	27.6±10.4	0.792
BMI	20.68±3.16	22.3±2.79	23±8.12	0.657	20.68±3.16	22.3±2.79	23±8.12	0.657
DF (c/min)	2.68±0.13	2.96±0.15	2.82±0.13	0.006	2.9±0.41	2.93±0.42	2.8±0.42	0.337
DFNR (%)	79.17±8.47	79.1±22.17	90.6±13.5	0.184	87.96±7.99	89.6±9.96	89.8±6.85	0.316
CVDF	0.37±0.24	0.3±0.12	0.2±0.12	0.063	0.21±0.09	0.23±0.15	0.32±0.24	0.581
DS (mV)	47.1±2.74	47.9±5.22	51.7±5.55	0.121	50.63±2.6	51.9±4.97	51.6±2.31	0.290
PPIIDS (%)					7.74±7.36	10±11.43	0.37±7.07	0.864
BG (%)	5.88±5.52	2.58±4.41	2.54±3.98	0.109	3.06±4.21	1.98±3.22	4.88±4.65	0.211
TG (%)	4.4±3.52	6.38±6.26	4.04±5.94	0.386	3.53±3.13	1.95±2.32	3±2.51	0.181
AR (%)	10.58±6.27	12±13.69	2.86±6.39	0.101	5.47±4.69	6.45±4.74	2.28±2.82	0.076

PreP – preprandial, PostP – postprandial, BMI – body mass index, DF – dominant frequency, DFNR – dominant frequency within normal range, CVDF – coefficient of variation for dominant frequency, DS – dominant strength, PPIIDS – postprandial increase intensity in dominant strength, BG – bradygastria, TG – tachygastria, AR – arrhythmia

TABLE 9
COMPARISON OF PREPRANDIAL AND POSTPRANDIAL CHARACTERISTICS OF GASTRIC MYOELECTRICAL ACTIVITY IN WOMEN ACCORDING TO MENSTRUAL CYCLE PHASE

	Menstrual cycle day 1–3			Menstrual cycle day 4–8			Menstrual cycle day 9–20		
	PreP	PostP	p	PreP	PostP	p	PreP	PostP	p
Subjects (n)	15	15		17	17		20	20	
Mean age (yrs)	31.57±10.45	31.57±10.45	1.000	31.2±8.4	31.17±8.4	1.000	27.6±10.36	27.6±10.36	1.000
BMI	20.68±3.16	20.68±3.16	1.000	22.3±2.79	22.27±2.8	1.000	23.01±8.12	23.01±8.12	1.000
DF (c/min)	2.68±0.13	2.9±0.41	0.123	2.96±0.15	2.93±0.4	0.916	2.82±0.13	2.8±0.42	0.883
DFNR (%)	79.17±8.47	87.96±7.99	0.154	79.1±22.17	89.6±10	0.188	90.58±13.51	89.82±6.85	0.821
CVDF	0.37±0.24	0.21±0.09	0.196	0.3±0.12	0.23±0.2	0.288	0.2±0.12	0.32±0.24	0.342
DS (mV)	47.1±2.74	50.63±2.6	0.024	47.9±5.22	51.92±5	0.063	51.74±5.55	51.64±2.31	0.905
BG (%)	5.88±5.52	3.06±4.21	0.089	2.58±4.41	1.98±3.2	0.746	2.54±3.98	4.88±4.65	0.236
TG (%)	4.4±3.52	3.53±3.13	0.566	6.38±6.26	1.95±2.3	0.141	4.04±5.94	3±2.51	0.714
AR (%)	10.58±6.27	5.47±4.69	0.181	12±13.69	6.45±4.7	0.205	2.86±6.39	2.28±2.82	0.728

PreP – preprandial, PostP – postprandial, BMI – body mass index, DF – dominant frequency, DFNR – dominant frequency within normal range, CVDF – coefficient of variation for dominant frequency, DS – dominant strength, PPIIDS – postprandial increase intensity in dominant strength, BG – bradygastria, TG – tachygastria, AR – arrhythmia

dominal wall surface. A higher rate of bradygastria, tachygastria and arrhythmia has been reported in individuals with greater BMI[13,14]. Some studies[20,21] describe an increased rate of bradygastria in subjects with increased BMI in comparison to those with normal BMI, whereas other studies performed in children found no such differences. Some studies performed in very obese subjects[22–24] report on accelerated gastric emptying tending to slow down with diet and weight reduction.

Functional examinations of the esophagus and anorectum have become an integral part of daily clinical practice, with a number of studies performed in Croatia to date[25–27], whereas gastric myoelectrical activity has not yet been studied in the Croatian population. Considering the controversial literature reports on the issue, we embarked upon the present study to assess the impact of age, sex, BMI and menstrual cycle phase on the gastric myoelectrical activity characteristics in our population. Determining the impact of these demographic and anthropometric factors on the gastric myoelectrical activity characteristics of the Croatian population would prove useful on interpreting EGG recordings in symptomatic patients and could be introduced in clinical practice as a new diagnostic method.

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UTJECAJ DOBI, SPOLA, INDEKSA TJELESNE TEŽINE I FAZE MENSTRUALNOG CIKLUSA NA ZNAČAJKE ŽELUČANE MIOELEKTRIČNE AKTIVNOSTI ZDRAVE HRVATSKE POPULACIJE

SAŽETAK

Cilj ove studije je bio odrediti utjecaj demografskih i antropometrijskih parametara na značajke mioelektrične aktivnosti želuca u zdravih ispitanika hrvatske populacije. Ispitivan je utjecaj dobi, spola, indeksa tjelesne mase (BMI) i faze menstrualnog ciklusa (MC) na značajke želučane mioelektrične aktivnosti. 120 zdravih ispitanika oba spola (60 muškaraca i 60 žena) podijeljeno je u četiri dobne skupine (18–35 godina, 36–50 godina, 51–65 godina i više od 65 godina), te prema BMI u tri skupine (BMI<25, 25–30, >30). Žene u generativnoj dobi su bile podjeljene u tri skupine ovisno o fazi MC (1–3. dan, 4–8. dan i 9–20. dan od početka menstruacije). Svim ispitanicima je učinjena perkutana elektrogastrografija (EGG). Snimanje se izvodilo 60 minuta prije te 60 minuta nakon uzimanja testnog obroka. Pratili su se slijedeći parametri mioelektrične aktivnosti želuca: dominantna frekvencija (DF), dominantna frekvencija unutar normalnog raspona (DFNR, %), koeficijent varijacije dominantne frekvencije (KVDF), dominantna snaga (DS, mV), postprandijalni intenzitet porasta DS (PPIPDS, %), bradigastrija (BG, c/min, %), tahigastrija (TG, c/min, %) i aritmija (AR). Životna dob utječe na DFNR, KVDF i AR u preprandijalnom periodu, dok nema utjecaja u postprandijalnom periodu. Utjecaj spola očituje se kroz slijedeće EGG parametre: DF, KVDF, DS i BG u preprandijalnom, te DF, KVDF, PPIPDS i TG u postprandijalnom periodu. Utjecaj BMI očituje se u TG i AR u preprandijalnom, te DF, KVDF i AR u postprandijalnom periodu. Utjecaj faze MC ogleda se u DF u preprandijalnom periodu, dok nije bilo utjecaja u postprandijalnom periodu.