Progress in Neuro-Psychopharmacology & Biological Psychiatry 34 (2010) 1294–1299

Contents lists available at ScienceDirect

Progress in Neuro-Psychopharmacology & Biological Psychiatry

journal homepage: www.elsevier.com/locate/pnp

Gastric dysmotility in healthy first-degree relatives of patients with schizophrenia

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ARTICLE INFO

Article history:
Received 28 April 2010
Received in revised form 13 July 2010
Accepted 13 July 2010
Available online 21 July 2010

Keywords:
Autonomic nervous system
Electrogastrography
Enteric nervous system
Schizophrenia
Vagal modulation

ABSTRACT

Gastric dysmotility has been reported in patients suffering from major depression or schizophrenia. An increased sympathetic activity modulating the gastric pacemaker located in the antrum of the stomach has been suggested as the underlying pathology. Similar to patients suffering from schizophrenia, their first-degree relatives showed alterations in cardiac autonomic modulation. Here we aimed to investigate gastric myoelectrical activity in healthy relatives of patients suffering from paranoid schizophrenia.

Electrogastrography (EGG) was performed before and after test meal ingestion in 20 patients with paranoid schizophrenia, 20 of their first-degree relatives and 20 healthy matched controls. Autonomic and abdominal symptoms were assessed by the autonomic symptom score as previously reported. Autonomic parameters were correlated with the positive and negative syndrome scale (PANSS).

Only minimal differences were observed before test meal ingestion between relatives and controls. In contrast, after test meal ingestion we observed a significantly increased tachygastria within the signal of the gastric pacemaker in relatives compared to controls, whereas normogastria was reduced. Significant difference between relatives and controls were also found for postprandial ICDF (instability coefficient of dominant frequency) and slow wave, which represents the dominant frequency of gastric pacemaker activity, indicating gastric dysmotility in relatives. Between relatives and patients just a difference for ICDP (instability coefficient of dominant power) was observed.

After stimulation of the enteric nervous system we have observed an increased sympathetic modulation in first-degree relatives of patients suffering from schizophrenia. This result adds evidence to an ongoing debate on the genetic influence of autonomic dysfunction in the disease.

1. Introduction

Previous studies have shown altered autonomic function in different peripheral structures of the autonomic nervous system (ANS) in patients suffering from paranoid schizophrenia (Bär et al., 2008). Here, a decreased vagal modulation was shown for the cardiovascular system as well as for cardio-respiratory coupling (Bär et al., 2007a; Peupelmann et al., 2009a). However, autonomic changes were also observed in pupillary function (Bär et al., 2008) and electrodermal activity has been the subject of intensive investigations in patients with schizophrenia (Zahn et al., 1999; Zahn and Pickar, 2005). Moreover, recent studies revealed autonomic alterations within the enteric nervous system of patients with schizophrenia (Peupelmann et al., 2009b).

Interestingly, some autonomic changes observed in patients with schizophrenia were reported for healthy first-degree relatives of patients as well (Bär et al., 2009; Berger et al., 2010; Castro et al., 2009). In particular, autonomic dysfunction was shown within the cardiovascular system by heart rate variability for acute psychotic patients as well as for their healthy first-degree relatives (Bär et al., 2009; Castro et al., 2009). The coupling between heart rate and respiration being a very sensitive method for the investigation of vagal modulation at brainstem level was similarly reduced in patients and relatives (Berger et al., 2010). Therefore, it has been suggested that autonomic dysfunction might represent not only a state but also a trait marker (Bär et al., 2009) and a genetic influence was proposed for alterations of autonomic function similar to previously reported abnormalities of eye movement in patients and their relatives (Takahashi et al., 2008; Calkins et al., 2004).

To further investigate the relation of autonomic dysfunction in patients with schizophrenia and their first-degree relatives we aimed

Abbreviations: ANOVA, Analysis of variance; ANS, Autonomic nervous system; DSM IV, Diagnostic and Statistical Manual of mental disorders, 4th edition; EGG, Electrogastrography; FPI, Freiburger Persönlichkeitsinventar; GMA, Gastric myoelectrical activity; HRV, Heart rate variability; ICDF, Instability coefficient of dominant frequency; ICDP, Instability coefficient of dominant power; MANOVA, Multivariate analysis of variance; PANSS, Positive and Negative Syndrome Scale; SCID II, Structured Clinical Interview II.

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doi:10.1016/j.pnpbp.2010.07.013

to investigate gastric myoelectrical activity (GMA) in first-degree relatives of patients suffering from paranoid schizophrenia. We hypothesized that increased amounts of tachygastria and arrhythmia as an indication of sympathetic modulation should be demonstrable according to previously investigated branches of the ANS. Therefore, we exploited cutaneous electrogastrography (EGG) in 20 first-degree relatives of patients suffering from paranoid schizophrenia, in respective patients and in controls. EGG is a non-invasive method for recording gastric myoelectrical activity. It was used by several investigators to study gastric emptying in different conditions, for example in diabetic gastroparesis and dyspepsia (Chen et al., 1993; Chen and McCallum, 1994). However, it also was applied in psychophysiological experiments investigating the influence of emotional arousal on gastric myoelectrical activity (Vianna and Tranel, 2006) as well as in patients with anorexia nervosa (Ogawa et al., 2004).

All the investigated subjects of our study were rated on an autonomic symptom score (ANS score) to interrelate clinical symptoms such as dyspepsia or abdominal discomfort to EGG parameters as previously shown for patients (Ruhland et al., 2008; Quick et al., 2010).

2. Methods

2.1. Subjects

We included 20 patients suffering from paranoid schizophrenia and their healthy first-degree relatives (7 siblings, including 2 males and 5 females; 13 offspring, including 3 males and 10 females) and 20 healthy controls matched to relatives in respect to age, sex, weight, smoking habits and education (see Table 1). Patients were included when they had not taken any medication for at least eight weeks. Six patients were investigated during the first episode and followed-up for 6 months to confirm the correct diagnosis. Serum drug levels were controlled for legal (e.g. antipsychotics, antidepressants, and benzodiazepines) and illegal drugs (e.g. cannabis). Diagnosis of paranoid schizophrenia was established when patients fulfilled DSM-IV criteria (Diagnostic and Statistical Manual of Mental Disorders, 4th edition, (First, 1997)). Psychotic symptoms were quantified using the Positive and Negative Syndrome Scale (PANSS, (Kay, 1987)).

All participants were seen by a gastroenterologist (M.H.) to exclude any potential disease. Control subjects were recruited from hospital staff (n = 5), medical students (n = 6) and the local community (n = 9). A careful interview as well as a clinical investigation was performed for all relatives and control subjects to exclude any potential psychiatric or other disease as well as interfering medication. The Structured Clinical Interview SCID II and a personality inventory (Freiburger Persönlichkeitsinventar, FPI) were additionally applied for relatives and controls to detect personality traits or disorders that might influence autonomic function (LeBlanc et al., 2004). In addition, we obtained an autonomic symptom score (ANS score, Ruhland et al, 2008; Peupelmann et al., 2009b), which includes the following symptoms: feeling of fullness, pyrosis, nausea, vomiting, dry mouth (xerostomia), diminished appetite, constipation, diarrhoea, palpitation, sweating, back pain, muscle pain, headache and abdominal pain. In addition, we assessed the severity of these symptoms (0 = no; 1 = mild; 2 = medium; and 3 = severe) (Table 1).

This study complied with the Declaration of Helsinki. All participants gave written informed consent to a protocol approved by the local Ethics Committee of the University hospital, Jena. Patients and relatives were advised that the refusal of participating in this study would not affect future treatment.

Table 1
Clinical and demographic data of participants.

Parameter	Controls	Relatives	Patients
Number of participants	n = 20	n = 20	n = 20
Male/Female	5/15	5/15	10/10
Age, mean ± SD (min–max), y	29.15 ± 10.01 (20–55)	26.80 ± 7.83 (18–51)	37.50 ± 11.94 (23–59)
Body mass index, mean ± SD	22.15 ± 2.59	22.86 ± 2.95	23.44 ± 3.52
Education			
8–10 years at school, No.	n = 5	n = 6	n = 11
12 years at school (A-level), No.	n = 15	n = 14	n = 9
Attended university, No.	n = 13	n = 7	n = 8
Smoker/Non-smoker	7 / 13	5 / 15	9 / 11
<5 cigarettes/day, No.	n = 2	n = 1	n = 2
5–10 cigarettes/day, No.	n = 3	n = 2	n = 3
>10 cigarettes/day, No.	n = 2	n = 2	n = 4
Coffee Consumption			
No coffee consumption, No.	n = 5	n = 6	n = 5
1 cup/day, No.	n = 6	n = 4	n = 3
2 cups/day, No.	n = 6	n = 7	n = 7
≥3 cups/day, No.	n = 3	n = 3	n = 5
Sport			
No sport, No.	n = 3	n = 6	n = 7
<2 h/week, No.	n = 8	n = 6	n = 6
2–5 h/week, No.	n = 6	n = 4	n = 3
>5 h/week, No.	n = 3	n = 4	n = 2
Sport not reported, No.	n = 0	n = 0	n = 2
Living together with ill relative, yes/no, No.	n.a.	n = 9/11	n.a.
First episode of psychosis, No.	n.a.	n.a.	n = 6
Duration of illness, years (min–max)	n.a.	n.a.	7.70 (0–25)
Age of onset, mean ± SD (min–max)	n.a.	n.a.	29.30 ± 7.61 (17–45)
PANSS, mean (min–max)	n.a	n.a.	72.30 (42.00–95.00)
Total ANS Score, mean ± SD	1.47 ± 2.34	3.40 ± 3.57	4.35 ± 3.89

PANSS — Positive and Negative Syndrome Scale; ANS score — autonomic symptom score; n.a. — not applicable; SD — standard deviation; No. — number.

2.2. Experimental task and procedure of EGG recordings

Participants were studied in the morning after an overnight fast. The electrogastrogram (EGG device; Medtronic, Minneapolis, USA) was recorded for 30 min in the fasting state and thereafter for another 30 min during standard meal digestion (200 ml Clinutren®, 300 kcal, Vevey, Switzerland). All four electrodes were positioned to follow the antral axis of the stomach using cutaneous electrodes.

The best results were obtained from channel 3, because it is positioned above the gastric pacemaker (Chen et al., 1994). Gastric slow wave is a measure for coupling of two EGG channels. In this paper, we calculated the slow wave parameter by coupling channel one, placed over the fundus region and channel three, positioned above the gastric pacemaker. Channel four was placed over the antrum region.

2.3. Data acquisition and pre-processing

EGG electrodes transmit the activity of the gastric pacemaker which is located in the corpus of the stomach (Chen et al., 1995). Signals of this pacemaker can be detected and various parameters described below have been suggested (Chen and McCallum, 1994; Chen et al., 1995). Therefore, those parameters are not independent from each other.

In the gastric pacemaker so called gastric slow waves are generated, which have a frequency of about 0.05 Hz. They determine the maximum frequency, propagation velocity and propagation direction of gastric contractions (Chen et al., 1995). Bauer et al. (1985) have shown that slow wave activity originates in the Auerbach's plexus region, where the interstitial cells of Cajal are located. Functionally, they may serve as mediators interposing between enteric nerves and smooth muscle cells (Huizinga, 2001). The percentage of slow waves reflects the regularity of gastric myoelectrical activity (Chen and McCallum, 1994). Sudden changes of their frequency have been observed and are generally considered to be related to gastric motility disorders.

Gastric dysrhythmias include bradygastria (0.5–2.4 cycle/ min), tachygastria (3.7–9.0 cycle/ min) and arrhythmia (0.5–9.0 cycle/ min). Bradygastria is mainly associated with vagal modulation. Tachygastria arises due to additional and external pacemaker activity located in the antrum of the stomach propagating retrograde to the corpus (Qian et al., 2003). Arrythmia is associated with a lack of a dominant frequency (Chen et al., 1995; Qian et al., 2003). An increased proportion of tachygastria and arrhythmia is supposed to be associated with an increased sympathetic modulation (Chen et al., 1993).

The instability coefficient of dominant frequency (ICDF) is a measure to ascertain the changes of dominant frequency during the period of data acquisition. It is defined as the coefficient of variation (%) (standard deviation of dominant frequency/mean dominant frequency * 100%) of dominant frequency (Pfaffenbach et al., 1997). Furthermore, the stability of the power of the dominant frequency, expressed as the instability coefficient of the dominant power (ICDP), was calculated. The ICDP is calculated by dividing the standard deviation of the power of the dominant frequency during a specific time-period (pre- or postprandially) by the mean dominant power during that time-interval. ICDF and ICDP are indicators of the stability of gastric electrical peak and reflect changes in gastric slow waves (Chen and McCallum, 1994).

2.4. Statistical analyses

For statistical analyses, SPSS for Windows (version 17.0) was used. The Kolmogorov–Smirnov test was used to test for normal distribution of obtained parameters. The natural logarithm was applied to produce a normal distribution of single EGG data. Thereafter, we performed a MANOVA to examine the overall differences between the groups before and after test meal ingestion.

Follow-up analyses of variance (ANOVAs) for single EGG parameters were calculated to demonstrate differences between relatives, controls and patients. We then performed a MANOVA for repeated measures (GROUP × TIME) to investigate the differences between the groups and time (before and after test meal).

To reveal differences between relatives, patients and control subjects for single parameters, a Bonferroni–Holm corrected *t*-test was performed as a post-hoc analysis. ANS score items were compared between controls and relatives as well as between relatives and patients using a *t*-test. Statistical significance was assumed for $p<0.05$.

In the patient group, ratings of psychopathological scales (PANSS) and the ANS score were correlated with EGG parameters. For correlation analysis we used a probability level of 0.01 for significance.

3. Results

3.1. Multivariate analysis of variance (MANOVA) and follow-up analysis of variance (ANOVA) of single parameters for all groups

The MANOVA comparing first-degree relatives, controls and patients in respect to the natural logarithm of normogastria, bradygastria, tachygastria, arrhythmia, ICDP, ICDF and slow waves revealed a significant overall difference between groups [$F(88,28)=1.9$; $p<0.009$].

The follow-up univariate ANOVA revealed a significant difference between groups for the natural logarithm of ICDP [$F=3.96$; $p<0.025$] before test meal ingestion. No differences were found for the natural logarithm of normogastria [$p<0.509$], bradygastria [$p<0.674$], tachygastria [$p<0.073$], arrhythmia [$p<0.593$], ICDF [$p<0.631$] and slow waves [$p<0.275$].

After test meal ingestion, significant differences for the natural logarithm of normogastria [$F=3.58$; $p<0.034$], tachygastria [$F=4.86$; $p<0.011$], ICDF [$F=3.7$; $p<0.031$], ICDP [$F=4.87$; $p<0.011$] and slow waves [$F=3.73$; $p<0.03$] were observed. No significant differences were found for the natural logarithm of bradygastria [$p<0.439$] and arrhythmia [$p<0.086$].

3.2. Multivariate analysis of variance (MANOVA) for repeated measures

The MANOVA for repeated measures revealed no interaction for GROUP × TIME [$F(102,14)=1.408$; $p<0.163$].

3.3. Post-hoc t-test of parameters between relatives, patients and controls

A Bonferroni–Holm corrected post-hoc *t*-test was performed for parameters showing a significant difference in the follow-up ANOVA. Mean values of parameters for all groups are depicted in Fig. 1 and Table 2.

3.3.1. Comparison of patients and controls

We found a significant difference for ICDP ($p<0.015$; Fig. 1) between patients and controls prior to the test meal. Patients and controls differed in respect to normogastria ($p<0.017$), ICDP ($p<0.006$) and slow waves ($p<0.016$) (Fig. 1) after ingestion of the test meal. No differences were found for tachygastria ($p<0.091$) and ICDF ($p<0.206$) between patients and controls. No further post-hoc comparisons were performed for any other parameter since follow-up ANOVAs did not reveal a significant overall difference between groups.

3.3.2. Comparison of relatives and controls

Relatives compared to controls showed a significantly increased ICDP before test meal ingestion. After test meal ingestion, a decreased amount of normogastria ($p<0.012$) and slow waves ($p<0.006$) as well as increased values of tachygastria ($p<0.044$) were found when relatives were compared to controls. No differences were observed for ICDP ($p<0.442$) and ICDF ($p<0.08$) after the test meal.

3.3.3. Comparison of patients and relatives

Comparing relatives and patients a significant difference was demonstrated for ICDP ($p<0.036$) only, being increased in patients after test meal digestion. No post-hoc comparisons for relatives and patients were performed for any other parameter since follow-up ANOVAs did not reveal a significant overall difference between groups.

3.4. Influence of personality traits on autonomic function in relatives

A significant difference between groups was found by means of a pair-wise comparison *t*-test in the FPI in the subscale "social orientation" ($p<0.010$) indicating that relatives were less socially oriented than controls. The SCID II revealed no differences between relatives and controls.

A significant correlation between the FPI subscale social orientation and ICDP ($r=-0.468$; $p<0.006$) was found before test meal ingestion for relatives. Postprandial, a correlation between aggressiveness and tachygastria ($r=0.409$; $p<0.01$) as well as between exposure and tachygastria ($r=0.419$; $p<0.01$) was observed for relatives.

3.5. Comparison of the ANS score between controls, relatives and patients

Comparisons of parameters of the ANS score by means of a *t*-test revealed that relatives complained significantly more often about sweating ($p<0.035$) in comparison to controls. No differences were found between relatives and patients. Patients complained slightly more often about abdominal pain in comparison to controls ($p<0.045$).

3.6. Correlation analysis between PANSS scores of patients and EGG parameters

We have not found a significant correlation between items of PANSS and autonomic parameters of EGG. In addition, autonomic

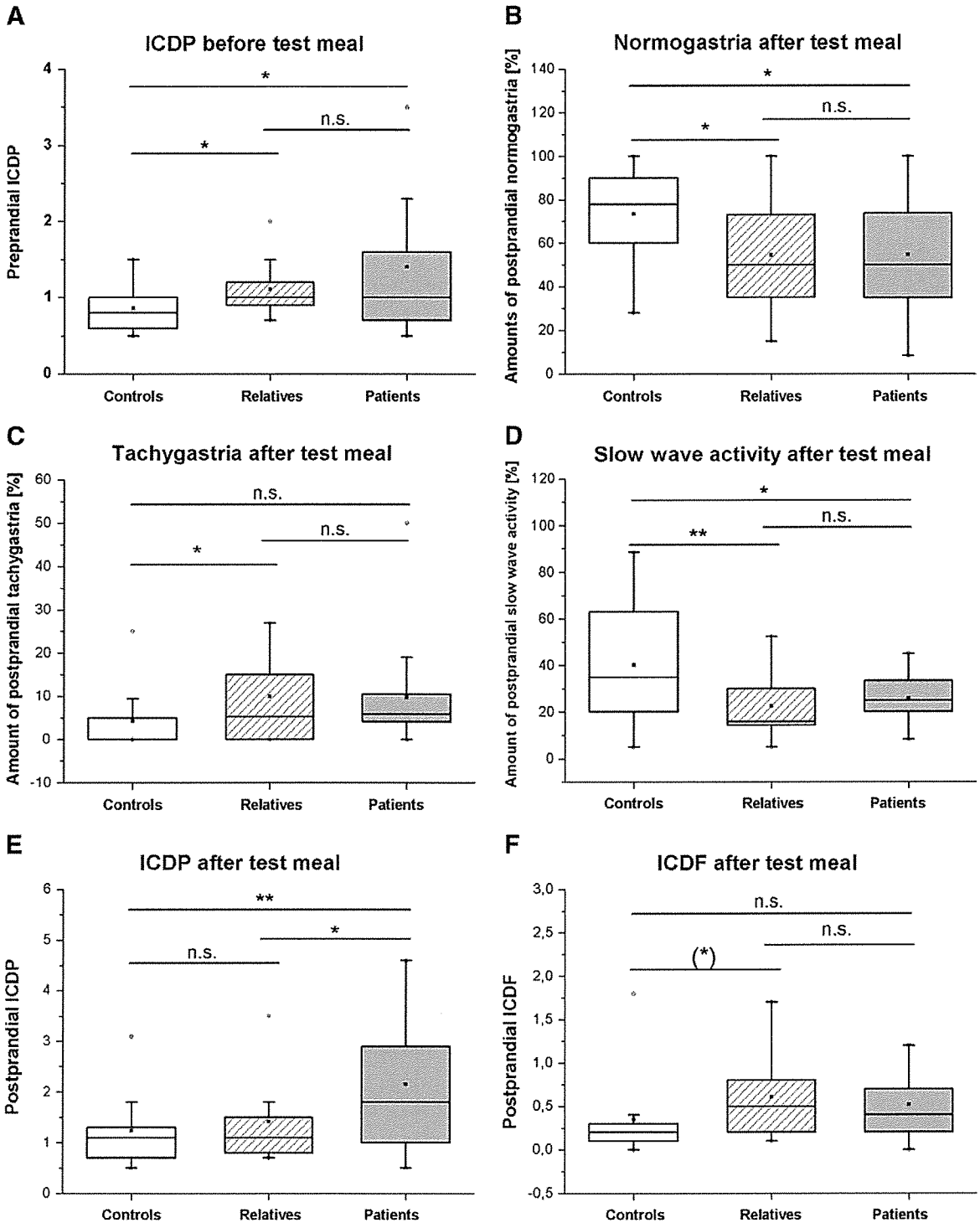

Fig. 1. EGG-parameters are displayed in Fig. 1. (A) Before test meal ingestion ICDP was increased in relatives and patients compared to controls. No difference was found between relatives and patients. After test meal ingestion, the percentage of normogastria (B) was decreased in relatives and patients, whereas the amount of tachygastria (C) was increased in relatives only when compared to controls. The activity of slow waves (D) was decreased in relatives and patients when compared to controls. There were no differences for ICDP (E) between relatives and controls, but values for patients were significantly increased when compared to relatives as well as to controls. Only a trend was observed when the values of ICDF of controls and relative were compared. Data presented as box plots. Boxes indicate 25th and 75th percentile with the horizontal line indicating the median, ■ mean, x minimum and maximum of data; (*)$p<0.08$; *$p<0.05$, **$p<0.01$.

parameters of EGG and items of the autonomic symptom score did not correlate in controls and relatives. In patients, a significant correlation between abdominal pain and ICDP ($r=0.704$; $p<0.001$) was observed before test meal ingestion.

4. Discussion

Many psychiatric illnesses are associated with an imbalance of the cardiac autonomic nervous system (Boettger et al., 2008; Agelink et

Table 2
Autonomic parameters of patients, relatives and controls obtained in the study.

Parameter	Controls	Relatives	p value	Patients	p value	p value
	Mean ± SD	Mean ± SD	(C vs. R)	Mean ± SD	(C vs. P)	(R vs. P)
Normogastria preprandial	70.8 ± 23.3	63.6 ± 29.5	p<0.39	62.9 ± 26.0	p<0.32	p<0.94
Normogastria postprandial	73.5 ± 20.4	54.5 ± 24.9	**p<0.012***	54.7 ± 27.0	**p<0.017***	p<0.984
Bradygastria preprandial	6.4 ± 11.4	8.2 ± 9.29	p<0.59	7.1 ± 9.4	P<0.84	p<0.71
Bradygastria postprandial	5.6 ± 5.6	10.3 ± 11.0	p<0.10	7.4 ± 10.9	p<0.53	p<0.41
Tachygastria preprandial	2.4 ± 3.9	5.7 ± 7.6	p<0.09	7.04 ± 6.9	**p<0.012***	p<0.56
Tachygastria postprandial	4.4 ± 7.9	9.97 ± 9.0	**p<0.04***	9.8 ± 11.5	p<0.091	p<0.96
Arrhythmia preprandial	20.4 ± 22.7	22.5 ± 22.9	p<0.77	23.0 ± 19.9	p<0.71	p<0.95
Arrhythmia postprandial	16.4 ± 20.1	25.5 ± 17.3	p<0.14	28.1 ± 19.5	p<0.07	p<0.65
ICDF preprandial	0.58 ± 0.6	0.4 ± 0.4	p<0.28	0.53 ± 0.58	p<0.79	p<0.40
ICDF postprandial	0.35 ± 0.46	0.6 ± 0.43	p<0.08	0.52 ± 0.37	p<0.21	p<0.51
ICDP preprandial	0.86 ± 0.3	1.1 ± 0.33	**p<0.013***	1.4 ± 0.92	**p<0.015***	p<0.18
ICDP postprandial	1.24 ± 0.7	1.4 ± 0.84	p<0.48	2.15 ± 1.21	**p<0.006****	**p<0.032***
Slow waves preprandial	32.7 ± 21.3	41.1 ± 26.4	p<0.27	30.6 ± 25.1	p<0.77	p<0.21
Slow waves postprandial	40.3 ± 23.	22.6 ± 13.4	**p<0.006****	25.7 ± 10.1	**p<0.016***	p<0.408

ICDF — instability coefficient of dominant frequency; ICDP — instability coefficient of dominant power; SD — standard deviation; C — controls; R — relatives; P — patients.
* p<0.05.
** p<0.01.

al., 2002; Bär et al., 2006; Bär et al., 2007b,c; Yeragani et al., 2000a; Koschke et al., 2009). This was demonstrated at rest (Schulz et al., 2010; Voss et al., 2006), during mental or physical strain (Boettger et al., 2009) and even at night times during sleep (Boettger et al., 2006; Yeragani et al., 2000b).

These alterations are very plausible, taking into account that vagal modulation is closely associated with emotional regulation and cognitive processing (Thayer and Sternberg, 2006). Interestingly however, similar results were observed in first-degree, healthy relatives of patients with schizophrenia (Bär et al., 2009; Berger et al., 2010). Castro et al. investigated 22 unaffected first-degree relatives of patients with schizophrenia and revealed an abnormal HRV response to mental arithmetic stress compared to controls (Castro et al., 2009).

Here we investigated the enteric nervous system in healthy first-degree relatives of patients suffering from schizophrenia. We were able to present some evidence after stimulation of the enteric nervous system by a test meal that healthy relatives differ in respect to gastric pacemaker activity from controls. In particular, we observed a significantly increased amount of tachygastria and a reduced amount of normogastria in relatives indicating an aberrant balance of sympathetic and parasympathetic modulation. These results suggest an increase of sympathetic and a decrease of parasympathetic modulation within the enteric nervous system in first-degree relatives as previously reported for patients with schizophrenia (Peupelmann et al., 2009b). Although patients were slightly older than their relatives, the range of age between groups did not differ significantly.

In addition, we have analysed whether relatives might share their homes with patients leading to increased perceived stress. As shown in Table 1, only half of our relatives lived together with patients and neither a statistical difference nor a trend was observed for autonomic parameters (data not shown). Thus reducing the likelihood that observed differences might be caused by direct daily stress.

Our study raises the question of clinical gastrointestinal implications in patients and their relatives. Apart from an increased occurrence of ulcers in patients with schizophrenia (Ozdemir et al., 2007) no other symptoms such as abdominal pain or constipation have been described in the disease. However, some items such as tachycardia or sweating were reported significantly more often from patients in our study. The generally low symptom rate might be caused by a lack of adequate introspection of patients (Jochum et al., 2006) in the acute stage or due to the known side effect of antipsychotics on enteric function (Pelizza et al., 2007; Raedler et al., 2007). However, we can exclude the latter in our study, since patients were not in receipt of antipsychotic medication. The correlative analysis indicated a connection between gastrointestinal symptoms of patients and sympathetic modulation.

Our results are limited by the relatively small sample size. Furthermore, we have investigated healthy relatives without any certainty whether relatives might develop a psychiatric disease in the future. A personality disorder or a prevailing trait according to performed tests was excluded, although the indicated decreased scores of social orientation in relatives might be associated with the higher frequency of schizotypical traits in this population. Our results are further limited by the age difference between patients and their relatives, since vagal function is age-dependent (Boettger et al., 2010) and since the control group was matched for the age of relatives. However, results shown for patients corroborate findings on autonomic dysfunction of previous studies (Peupelmann et al., 2009b).

The postprandial reduction of normogastria as well as the increase of tachygastria in patients and relatives putatively refers to an impaired vagal modulation and an increased sympathetic modulation. Thus, autonomic regulation is not only altered in the cardiovascular branch of the ANS in patients and relatives but moreover in the enteric nervous system. As described above, only very few studies were performed to investigate the gastrointestinal tract in patients with schizophrenia (Ozdemir et al., 2007; Peupelmann et al., 2009b). Apart from an increased occurrence of ulcers no other symptoms such as abdominal pain or constipation have been described in the disease. Whether a reduced vagal modulation here is of clinical significance needs to be addressed in future studies. In particular, gastric emptying should be analysed to learn whether clinical consequences as described for the cardiovascular system have to be taken into account.

Furthermore, if autonomic dysfunction represents not only a state but also a trait marker a genetic influence needs to be assessed. Ideally, different branches of the autonomic nervous system should be analysed in relatives and patients at rest and during stress to allow the investigation of heritability. A genetic determination of heart rate variability (HRV) is assumed to range from 13% to 39% at rest, but can increase up to 51% when recorded during exposure to various stress tasks (Snieder et al., 1997; Tank et al., 2001).

To our knowledge this is the first study investigating the gastric myoelectrical activity in healthy first-degree relatives of patients suffering from schizophrenia. Observed results are similar to patients and might suggest a genetic background of autonomic dysfunction. Underlying neurobiological correlates of the autonomic imbalance in patients and their relatives need to be addressed in future studies.

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