

## ORIGINAL ARTICLE

## Effects of acupressure on gastric myoelectrical activity in healthy humans

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**Objective.** Acupressure at Neiguan point (P6) has been used as an antiemetic in Eastern countries and many studies have reported its effectiveness on gastrointestinal symptoms. The aim of the present study was to investigate the effects of acupressure on gastric myoelectrical activity in healthy humans. **Material and methods.** Fifteen healthy volunteers (9 M, 6 F) served as subjects. Acupressure at P6 was applied for 1 min followed by 1 min of rest, and this alternating sequence was continued for a total of 30 min. Electrogastragram (EGG) was recorded for 30 min before (“baseline”), during (“acupressure”) and after (“recovery”) the application of acupressure. Heart rate variability (HRV) was also recorded to analyze autonomic nervous activities. **Results.** The percentage of normal 3 cycles per minute slow wave (%NSW) was changed significantly by the application of acupressure ( $86.5 \pm 2.4$ ,  $92.3 \pm 1.2$ ,  $92.8 \pm 1.9\%$  in the baseline, acupressure and recovery periods, respectively,  $p = 0.0424$ ). The %NSW was significantly larger in the acupressure and the recovery periods than in the baseline period ( $p < 0.03$ ). The changes in %NSW from the baseline to the acupressure ( $r = -0.8598$ ,  $p < 0.001$ ) and to the recovery ( $r = -0.6422$ ,  $p < 0.01$ ) periods were negatively correlated with the baseline %NSW. There was no change in HRV. **Conclusions.** Acupressure at P6 increased %NSW of gastric myoelectrical activity. The negative correlation between the baseline value and the change in %NSW may extrapolate a possible normalizing effect of acupressure on impaired gastric myoelectrical activity in symptomatic patients.

**Key Words:** Acupressure, Electrogastragram, electrogastrography, Neiguan point (P6)**Introduction***Acupressure*

Acupressure is a common technique of applying finger pressure on acupressure/acupuncture points and has been used for gastrointestinal symptoms in Eastern cultures [1]. The most commonly used points for gastrointestinal symptoms are the Neiguan (P6) and the Zusanli (ST36) points. The present study focused on P6, which is located in the wrist [1].

Acupressure at P6 is used as a prophylaxis against vomiting in early pregnancy in China [1] and is documented as effective in reducing symptoms of morning sickness [2,3]. Some studies have reported a reduction in the incidence of both nausea and vomiting with acupressure at P6 in postoperative patients [4,5]. However, other studies have indicated

that acupressure at P6 is effective only in reducing nausea but not in reducing the severity and incidence of vomiting [6,7].

*Electrogastrography*

Electrogastrography is a method of recording gastric myoelectrical activity from surface electrodes placed on the abdomen. In healthy subjects, the electrogastragram (EGG) has the dominant frequency of 0.05 Hz or 3 cycles per minute (cpm) with an amplitude of several hundred microvolts [8,9]. Two kinds of gastric myoelectrical activities are measured by serosal or transmural electrodes: the slow wave (electrical control activity, basic electrical rhythm, pacesetter potential) and spikes (electrical response activity) [9]. The slow wave controls the rhythm and

propagation of contraction, but is not indicative of contraction activity itself. Spikes are directly correlated with antral contraction. When the gastric slow wave is superimposed with spikes, an antral contraction occurs [9]. Electrogastrography picks up the rhythm of the slow wave but not that of the spikes. The spikes are reflected in the EGG as an increase in amplitude [10]. Validation studies using internal electrodes have demonstrated that the dominant frequency of 3 cpm in the EGG accurately reflects the frequency of the slow wave activity [11,12].

The rhythm of gastric slow waves may be altered in various diseases with gastrointestinal symptoms such as idiopathic gastroparesis [13,14], *Helicobacter pylori* infection [15,16], systemic sclerosis [17], and motion sickness [18–21]. The normal slow waves disappear and waves with frequencies lower than 2 cpm (bradygastria) and/or higher than 4 cpm (tachygastria) are observed. A lower percentage of normal slow waves predicts abnormal motility of the stomach [13]. The severity of motion sickness is correlated with the power of tachygastria in a rotationalvection drum study [19]. Kono et al. reported a decrease in the percentage of normal slow waves and an increase in tachygastria among motion-sick subjects who were exposed to Coriolis stimulation [20]. Vector analysis of the EGG also revealed a decreased regularity of gastric normal slow waves during motion sickness [21]. Accordingly, it is speculated that the effects of P6 acupressure on gastrointestinal symptoms are related to the changes in gastric slow wave activity.

Electroacupuncture increased normal 3-cpm slow waves and reduced gastric arrhythmia in patients with dyspepsia [22]. Transcutaneous electrical nerve stimulation (TENS) at P6 decreased tachygastria in motion-sick subjects who were exposed to an optokinetic drum [23]. It was speculated that electrical stimulation at P6 reduced nausea and vomiting through the normalization of electrical activity of the stomach by a mechanism which is yet unclear.

To the best of our knowledge so far, the effects of acupressure on gastric electrical activity have not yet been reported. It was speculated that acupressure on P6, like acupuncture and TENS, would enhance gastric electrical activity; i.e. increase the percentage of normal 3-cpm gastric slow waves and reduce gastric dysrhythmia in normal subjects. Gastric myoelectrical activity was evaluated by means of electrogastrography.

## Material and methods

### *Study design*

A single group, repeated measures, pre-post test design was used to compare gastric myoelectrical

activity before, during, and after the application of acupressure at P6.

### *Study subjects*

The study protocol was in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of the University of Texas Medical Branch at Galveston (UTMB) prior to the data acquisition. Each subject was fully informed of the purpose of the study and potential risks prior to the participation in the study, and informed consent was obtained from each subject. Seventeen healthy volunteers participated in the experiment as subjects (10 M, 7 F; median age 36 years, range 29–43 years). No fee was paid for participation. All subjects had fasted for more than 6 h and had taken no medications with known effects on gastrointestinal motility for 3 days before the experiment.

### *Acupressure at P6*

Acupressure at P6 was applied in the non-dominant forearm of each subject. P6 is located 2 “cun” or approximately 3 cm proximal from the distal wrist crease between the tendons of the palmaris longus and the flexor carpi radialis muscles (Figure 1A) [1]. Pressure was applied using a 3-pound dumb-bell via a small plastic ball (Figure 1B) for 1 min, followed by 1 min of rest. This sequence was alternated for a total of 30 min; i.e. 15 min of acupressure and 15 min of rest in alternating 1-min increments.

### *Electrogastrogram*

Surface EGG was recorded using a multichannel recording device (Medtronic-Synectics, Shoreview, Minn., USA). This device consists of four identical amplifiers with cut-off frequencies of 1.8 and 16.0 cpm. The data were converted from analogue to digital form with a sampling frequency of 4 Hz on-line and stored on an IBM-compatible computer.

The EGG recording consisted of three parts: a 30-min “baseline” period at rest, a 30-min “acupressure” period, and a 30-min “recovery” period. Subjects remained supine and were required to remain motionless in order to avoid possible artifacts derived from body movements. Four-channel EGG was recorded using silver/silver chloride electrodes (BioTac<sup>®</sup> Ultra Foam; Kendall-LTP, Chicopee, Mass., USA) placed on the abdomen. Electrode positions were as follows: four active electrodes (electrode 3: 2 cm above the mid point between the xiphoid process and the umbilicus; electrode 4: 4 cm to the right of electrode 3; electrode 2: 4 cm 45° upper left to electrode 3; electrode 1: 4 cm 45° upper left to electrode 2), a reference electrode (at

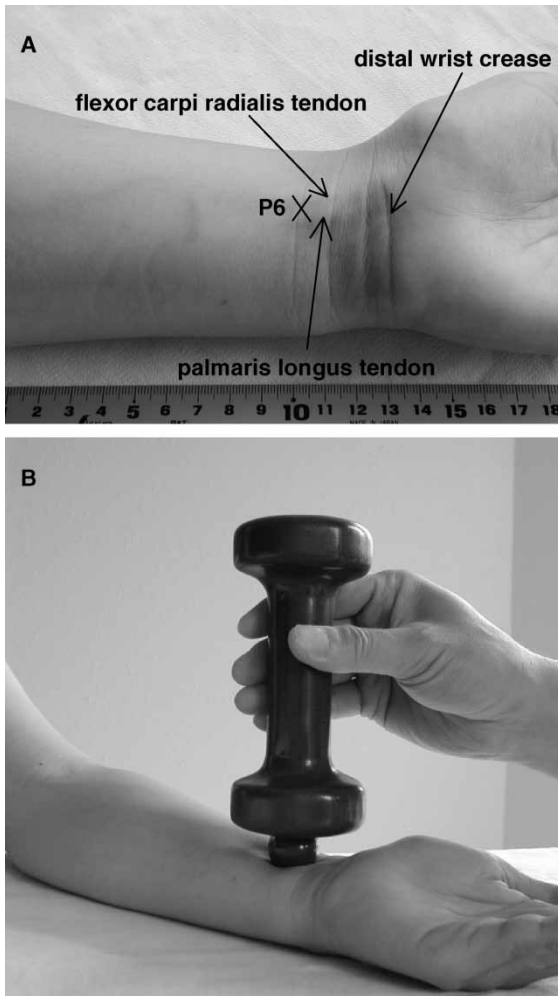


Figure 1. Acupressure at Neiguan point (P6). A. P6 is located approximately 3 cm proximal to the distal wrist crease between the tendons of the palmaris longus and the flexor carpi radialis. B. A 3-pound dumb-bell with a small plastic ball was used to apply a semi-constant pressure at P6. The dumb-bell was lightly supported by an examiner.

the cross point of a horizontal line on electrode 1 and a vertical line on electrode 3), and a ground on the left costal margin. The skin was lightly abraded with sandy paste (Omni Prep; D.O. Weaver & Co., Aurora, Colo., USA) before the placement of electrodes.

#### Data analysis

The flow chart of the analysis is shown in Figure 2. The data were analyzed digitally on an IBM-compatible computer. Data were digitally filtered using a finite impulse response low-pass filter [24]. The number of order was 100th and the cut-off frequency was set at 10 cpm. The EEG signal is so weak that any contamination with artifacts or noises can alter the estimated spectrograms. Thus all the filtered data were subject to visual inspection by one of the

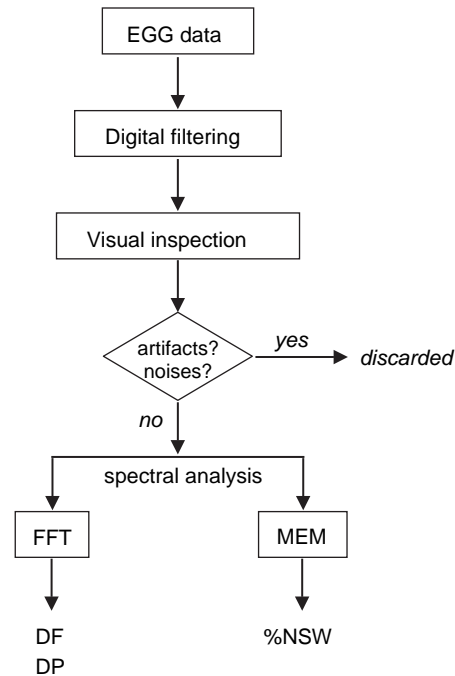


Figure 2. Flow chart of the data analysis. The electrogastrogram (EGG) signal was recorded at a sampling frequency of 4 Hz. After digital low-pass filtering (cut-off frequency: 10 cpm); data contaminated with artifacts or noises were excluded from the following spectral analysis. Fast Fourier transform (FFT) was used to calculate the dominant frequency (DF) and the dominant power (DP). Percentage of normal slow wave (%NSW) was calculated by the maximum entropy method (MEM).

investigators (TO), and 4-min epochs contaminated with artifacts or noises were excluded from the following analysis. If more than 20% of the epochs were discarded, that subject was excluded from the analysis. The following two kinds of spectral analyses were conducted accordingly.

*Fast Fourier Transform (FFT).* FFT gave a linear estimation of a power spectrum. An epoch length was 256 s (240 s of data followed by zeros for 16 s) with a sampling frequency of 4 Hz. Raw spectra were smoothed by the Hanning window and arithmetical averaging [25]. Power spectra estimated by FFT were used to calculate dominant frequency (DF) and dominant power (DP) (described below).

*Maximum entropy method (MEM).* In calculating the percentage of normal slow wave (%NSW, described below), minute-by-minute spectra with a higher resolution in frequency domain were needed than could be reached with FFT. Therefore, running spectrograms were estimated by MEM [25] with an epoch length of 60 s. The order of MEM was determined so that the final prediction error (FPE) was minimal for each subject [26].

The transformed signals were analyzed and the following parameters compared.

**Percentage of normal slow waves.** The percentage of normal slow waves (%NSW) is defined as the percentage of time during which regular 2–4 cpm slow waves are present over the entire recording period [9]. More precisely, when a given 1-min spectrum estimated by MEM has a peak in the frequency range of 2–4 cpm (including both ends) in any channel, that 1-min epoch is defined as having normal slow waves. If no peak exists between 2 and 4 cpm, it is defined as dysrhythmia. If the largest peak is found between 0.5 and 2 cpm, it is defined as bradygastria; if found between 4 and 9 cpm, it is defined as tachygastria. When no peak is found between 0.5 and 9 cpm, it is called arrhythmia.

**EGG dominant frequency and power.** The frequency at which the EGG power spectrum estimated by FFT has a dominant peak power in the range of 0.5–9.0 cpm is defined as the EGG dominant frequency (DF) [9]. The power at the dominant frequency is defined as the EGG dominant power (DP) [9]. DP is expressed in decibel (dB) units. Assuming a sinusoidal signal with an amplitude of  $A$  [ $\mu\text{V}$ ], the power  $P$  [dB] is given as follows.

$$P = 10 \log_{10} A^2 \text{ (or } 20 \log_{10} A)$$

#### Heart rate variability

Heart rate variability (HRV) is an analysis of the variation of R-R intervals of electrocardiogram (ECG). HRV is one of the most promising markers of autonomic nervous activity [27]. Power components between 0.04 Hz and 0.15 Hz (LF) and between 0.15 Hz and 0.4 Hz (HF) are the main derivatives in frequency domain from short-term recordings. The efferent vagal activity is a major contributor to the HF component. The LF/HF ratio is considered to mirror sympathovagal balance or to reflect the sympathetic modulations.

ECG was recorded from silver/silver chloride electrodes placed on the thorax (similar to lead III), and the data were recorded on an IBM-compatible personal computer with a sampling frequency of 6000 Hz. The data were re-sampled at 500 Hz before they were subject to the detection of R waves and the subsequent spectral analysis of R-R intervals. Power spectra were calculated using an autoregressive moving average (ARMA) model.

#### Statistical analysis

Data were compared among “baseline”, “acupressure”, and “recovery” periods using a repeated measures ANOVA model followed by *post-hoc* tests to compare the means, and each subject served as his/her own control. Data were not always normally distributed, and a non-parametric test (Wilcoxon signed-rank test) was also used in multiple comparisons with Bonferroni’s correction.

The alpha level was set to 0.05. Data were presented as means  $\pm$  SE unless otherwise described. All statistical tests were computed using statistical analysis software JMP IN version 3.2.6 (SAS Institute, Cary, N.C., USA).

Assuming the standard deviation of %NSW is similar to those of a previous study [22], the study was originally designed to have a statistical power of 80% to detect a difference of 7% in %NSW, given a sample size of 17 and a standard deviation of 10.

#### Results

Two subjects (1 M, 1 F) were excluded from the following analyses because more than 20% of epochs were discarded by the visual inspection of EGG. Thus the number of subjects included was 15 (9 M, 6 F, median age 35 years, range 29–43 years).

#### Percentage of normal slow waves

The %NSW was significantly different among the baseline, the acupressure and the recovery periods ( $86.5 \pm 2.4$ ,  $92.3 \pm 1.2$ ,  $92.8 \pm 1.9\%$ , respectively;  $F_{2, 13} = 4.0720$ ,  $p = 0.0424$ , Wilks’ lambda) (Figure 3). *Post-hoc* tests revealed that %NSWs were significantly larger in the acupressure

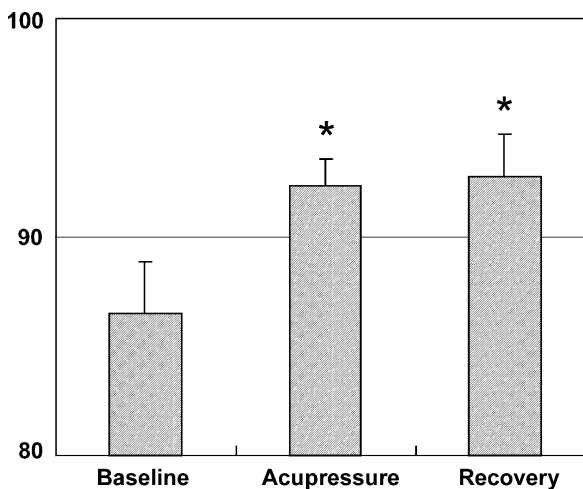


Figure 3. Effects of acupressure on the percentage of normal slow waves ( $p = 0.0424$ ). \* :  $p < 0.03$  compared with the baseline period (by Bonferroni’s correction).



and the recovery periods than in the baseline period ( $p < 0.03$ , Wilcoxon signed-rank test with Bonferroni's correction, respectively). No difference was found between the acupressure and the recovery periods.

The values of %NSW in the baseline period were negatively correlated with the changes in %NSW from the baseline to the acupressure period ( $r = -0.8598$ ,  $p < 0.001$ ) and the changes in %NSW from the baseline to the recovery period ( $r = -0.6422$ ,  $p < 0.01$ ) (Figure 4).

#### Dominant frequency and power

No change in DF was observed by application of acupressure ( $2.77 \pm 0.08$ ,  $2.75 \pm 0.05$ ,  $2.73 \pm 0.07$  cpm, respectively;  $F_{2, 13} = 0.4095$ ,  $p = 0.6722$ ). Nor was there any change observed in DP ( $31.6 \pm 0.9$ ,  $33.9 \pm 2.4$ ,  $30.1 \pm 0.8$  dB, respectively;  $F_{2, 13} = 1.9485$ ,  $p = 0.1819$ ).

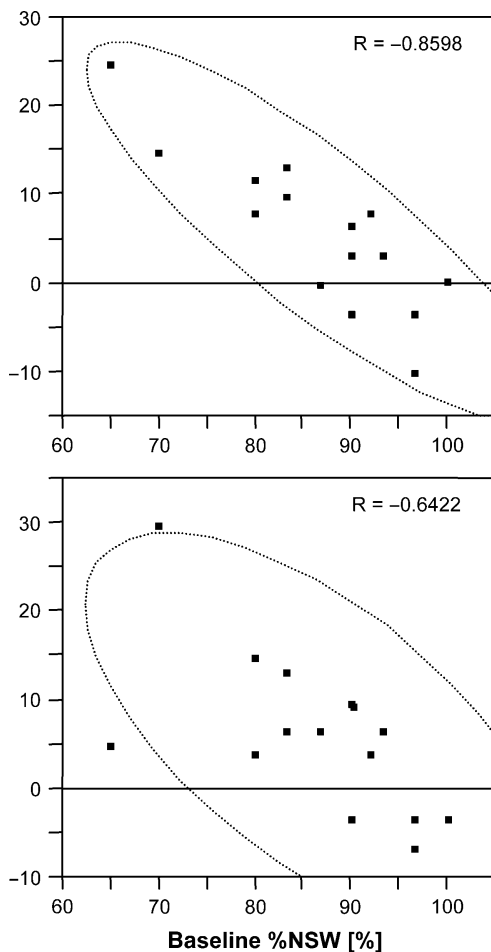


Figure 4. The baseline values of percentage of normal slow waves were negatively correlated with the changes in percentage of normal slow waves from the baseline to the acupressure period (upper:  $r = -0.8598$ ,  $p < 0.001$ ) and from the baseline to the recovery period (lower:  $r = -0.6422$ ,  $p < 0.01$ ). Dashed lines indicate the 95% density ellipsoids.

#### Heart rate variability

No difference in HF was observed among the baseline, the acupressure, and the recovery periods ( $F_{2, 13} = 2.2336$ ,  $p = 0.1466$ ). The LF/HF ratio did not change significantly between those three periods ( $F_{2, 13} = 0.6594$ ,  $p = 0.5336$ ).

Changes in HF from the baseline to the acupressure period and those from the baseline to the recovery period were not correlated with corresponding changes in %NSW ( $r = 0.3323$ ,  $0.2975$ , respectively). Changes in LF/HF from the baseline to the acupressure period and to the recovery period were not correlated with corresponding changes in %NSW, either ( $r = -0.1570$ ,  $0.0427$ , respectively).

#### Discussion

Effects of P6 acupressure on gastric electrical activity in healthy subjects were studied by means of electrogastronomy. The %NSW was significantly increased in the acupressure and the recovery periods. The changes in %NSW by the application of acupressure were negatively correlated with the baseline value of %NSW; i.e. the lower the baseline %NSW, the greater the increase in %NSW by the acupressure. PF and PD did not change significantly. HF and LF/HF were not changed by acupressure at P6. There was no correlation between HRV and EGG parameters.

Acupressure, acupuncture, and TENS were reported to be effective in reducing gastrointestinal symptoms of morning sickness [2,3], postoperative complications [1,4,5,28–30], chemotherapy [31,32], and motion sickness [23]. Therefore, it was speculated that impaired gastric slow waves in those disorders [18–21] might be normalized, as gastrointestinal symptoms were reduced by acupressure, acupuncture, or TENS at P6. In fact, improvements in gastric dysrhythmia with electroacupuncture [22] and TENS [23] were reported. In the present study we investigated the effect of acupressure on EGG in gastrointestinally asymptomatic subjects and a significant increase in EGG normal slow wave was observed by application of acupressure. It was found interesting that the changes in %NSW evoked by the application of acupressure were negatively correlated with the baseline values of %NSW.

One interpretation could be that, in subjects whose gastric myoelectrical activity was already near 100% before acupressure was applied, further improvement was hardly possible, whereas subjects with lower %NSW or somewhat impaired gastric myoelectrical activity (but still asymptomatic) presented an increase in EGG normal slow wave. An

extrapolation could be that reduced gastric %NSW in symptomatic patients is increased by the application of acupressure; i.e. impaired gastric myoelectrical activity could be “normalized”. A study on patients with gastrointestinal symptoms would be the next step.

Dundee and his colleagues have reported the effectiveness of acupuncture/acupressure in preventing and reducing nausea and vomiting related to surgery [1,5,28], chemotherapy [31,32], and morning sickness [2] among gynecological patients. Since their patients were all from the gynecological department, their results were based only on female subjects and the results may not be applicable to male subjects. Some researchers reported that acupressure was not effective in reducing the severity of motion sickness among male subjects [33,34]. McMillan studied the effect of TENS as an adjunct to antiemetics in patients receiving postoperative opioid analgesia and found that it was effective only in females [29]. In the present study, an increase in %NSW was observed by acupressure both in male and female subjects.

Dundee et al. [5] reported that acupressure was effective in reducing postoperative nausea only during the first hour after the application. In the present study, increased %NSW was sustained during the 30-min recovery period. However, it was not investigated in this study whether or not the effect was sustained thereafter.

Dundee et al. reported that acupressure at P6 on the right forearm was more effective in right-handers than in left-handers [35,36]. Although their study was limited to the application of acupressure on the right side, it is possible that acupressure might be more effective when applied on the dominant side than on the non-dominant side. Acupressure in the present study was performed on the non-dominant side in all subjects. Accordingly, a possible effect of dominant versus non-dominant sides was removed. But the observed effects might have been greater if acupressure had been applied in the dominant side.

Acupressure in this study was applied using a 3-pound dumb-bell. In clinical settings, acupressure is applied manually by the practitioner, and the pressure is controlled on a case-by-case basis (Ouyang, personal communication). In experimental settings, acupressure was applied manually [2,4,6] or by using wristband devices [3,5,7,33,34]. No data were provided regarding the pressure or force actually applied at P6 in those studies. In the present study, the weight applied at P6 was estimated to be 100–93.9% of the dumb-bell weight if it was held lightly and the deviation from the vertical line was less than 20°, which was always the case in executing the experiment. Thus, the applied force was rela-

tively constant with an estimated error of less than 6.1%.

It has been reported that sympathetic activation is associated with tachygastria while parasympathetic activity is associated with normal slow wave activity [18]. In the present study, despite the changes in EGG, no change was observed in HRV by the application of acupressure. No correlation between the EGG and HRV parameters was observed either. In their electroacupuncture study, Ouyang et al. [37] reported increased normality of gastric slow wave and accelerated gastric emptying in association with an enhancement of vagal tone. They speculated a possible involvement of the vagal pathway in the effectiveness of acupuncture on gastric motility.

In conclusion, acupressure at P6 increased %NSW in healthy subjects. Such increase was negatively correlated with the baseline value of %NSW; i.e. the lower the baseline value of %NSW, the greater the increase in EGG normal slow wave activity by the application of acupressure. An extrapolation of this finding might suggest a possible normalizing effect of acupressure on gastric myoelectrical activity in gastrointestinally symptomatic patients. No significant effect on HRV was observed.

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