Whole-Body Vibration Suppresses Gastric Motility in Healthy Men

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Received November 7, 1997 and accepted December 22, 1997

Abstract: The influence of whole-body vibration on gastric motility was investigated by using an electrogastrography (EGG) in seven healthy men. The EGG is usually referred to as a noninvasive technique of recording gastric myoelectrical activity by means of placing electrodes on the abdominal surface. Sinusoidal vertical vibration at each of 3 different frequencies (10 Hz, 20 Hz, 40 Hz) were randomly given to the subject seated on a platform of vibrator for 5 min. The vibration magnitude was kept at a constant of 2.0 msec^{-2} (r.m.s.) during operation. The mean dominant frequency of EGG at control period was prior to operation 3.3 cycles per min (cpm). During vibration exposure at 10 Hz, the peak of dominant frequency increased to 3.9 cpm, and the relative power of slow wave showed the statistically significant decrease (45.8%, $p < 0.05$). The mean relative power of slow wave which is composed of frequencies ranged from 2.0 to 5.0 cpm was 56.6% at control period. On the contrary the mean relative power of frequencies ranging from 5.0 to 9.0 cpm, tachygastria increased from 29.5% to 39.1%. These results suggest that the short-term exposure to whole-body vibration effects on the gastric myoelectrical activity.

Key words: Electrogastrography (EGG), Gastric motility, Whole-body vibration

Introduction

According to several epidemiological studies, long-term whole-body vibration (WBV) exposure can be associated with a high prevalence of low-back pain^{1–3}. And also a high frequency of the gastrointestinal disorders has been observed among workers with WBV-exposure^{4, 5}. However, there has been a big problem whether WBV is a specific risk factor against the gastric disorders such as gastric neurosis, gastric ulcer and duodenal ulcer. Few experimental studies have been reported concerning the human gastrointestinal responses to WBV⁶.

Cutaneous electrogastrography (EGG) is a potentially useful noninvasive technique for evaluating the gastric motility controlled by myoelectrical activity of the stomach^{7–10}. The

gastric slow motions are present at all the time, originating from the part of the corpus and propagating through the longitudinal muscle fiber to the pylorus. The human gastric signal composed of bradygastria (0.5–2.0 cpm), slow wave (2.0–5.0 cpm) and tachygastria (5.0–9.0 cpm)¹¹. Gastric dysrhythmias except slow wave are believed to be associated with gastric dysmotility¹¹.

The aim of this study was to assess the short-term effect of whole-body vibration exposure on the gastric motility using by the cutaneous electrogastrography.

Materials and Methods

Subjects

Seven male medical students with a mean age of 24.5 yr (range 22–28 yr) participated in this study. They had no history of disorders of the upper gastrointestinal tract motility.

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Smoking and taking coffee were prohibited for 6 hr before the experiments. All subjects were carefully explained about this study prior to the study, and written consent forms were signed by each of them.

Vibration exposure

Subjects were asked to sit on the vibration platform without backrest in the comfortable posture. The vibration stimulus was produced by using an electromagnetic shaker (ASE-385; AKASHI, Japan). The sinusoidal vibrations with three different frequencies, 10 Hz, 20 Hz and 40 Hz, were randomly given to the subject for 5 min. The magnitude of vibration was constantly kept at 2.0 msec^{-2} (r.m.s.).

Measurement of electrogastrography (EGG)

The recording sites on the abdominal surface was lightly cleaned with ethanol and abraded with sandy skin paste to reduce skin-electrode motion artifacts. Two disposable AG/AgCl electrodes (Vitrode, Nihon Kohden, Japan), 6 cm apart, were placed at the horizontal and one-fourth apart from the median between the xiphoid and the umbilicus. The EGG signals were amplified and filtered (0.03 to 0.2 Hz) by a pre-amplifier (AB621-G, Nihon Kohden, Japan), and also digitized and stored simultaneously on the IBM computer with a sampling frequency of 2 Hz.

Experimental protocol

To eliminate the effects of biorhythm and meal on the

EGG, each study commenced at about 5:00 in the afternoon. All subjects were asked nothing to eat and drink after an ordinary lunch. The mean fasting time was 4.5 hr. The subjects divided into two groups randomly were exposed to vibration in the order of 10, 20 and 40 Hz in frequency for 5 min. The one group took vibration with the above-mentioned order and the other was exposed to vibration in the reversed order. The EGG data for 5 min were recorded before, during and after vibration exposure. During the operation, the noise level induced by the electromagnetic shaker was 72 to 74 dB(A). The experimental room temperature was maintained at 22°C to 24°C.

Data analysis

Frequency analysis of EGG was done using fast Fourier transform (FFT). Power spectrum was calculated every 5-min-recording. Two EGG parameters were used for evaluation: 1) the mean dominant frequency of the EGG which may reflect the frequency of the slow wave, 2) the relative power changes of the slow wave (2–5 cpm) and tachygastria (5–9 cpm).

Statistics

The statistical evaluation of EGG was assessed by paired t-test. Differences were considered to be significant at $p < 0.05$.

Results

Figure 1 indicates a typical waveform of EGG (A) and

Fig. 1. Typical surface electrogastrogram (A) and its power spectrum (B) obtained in a healthy man under the condition of non-exposure of whole-body vibration

its power spectrum (B) before vibration exposure. A regular and rhythmic EGG waveform was recognized. In the power spectral density, two peaks were observed. The big component was around 3 cpm in frequency which we called the slow wave component, showing the dominant frequency of 3.7 cpm. The small and fast wave component was the frequency of 5 to 9 cpm. Six of 7 subjects (86%) showed the slow wave component with frequency of 2 to 5 cpm. Typical changes of EGG waveform and its power spectra induced by whole-body vibration of 10 Hz in a subject are shown in Figure 2. The power of spectrum corresponding to the slow wave component was suppressed by vibration exposure. On the other hand, the power of fast wave component, tachygastria, increased relatively. When the vibration exposure finished, the composition of such components recovered to the previous constitution with

slightly increased power.

The mean dominant frequency of EGG was 3.3 cpm at control period, composing of 56.6% of slow wave and 29.5% of fast wave one (Table 1). The dominant frequency increased during vibration exposure except of 20 Hz. However, these changes were not statistically significant. During vibration exposure of 10 Hz, the slow wave decreased from 56.6% to 45.8% with a significant difference ($p < 0.05$) and increased after vibration exposure ($p < 0.05$). However, the relative power was scarcely changed under the condition of the exposure to the frequency of 20 and 40 Hz. On the contrary the tachygastria (5–9 cpm) at 10 Hz increased from 29.5% to 39.1% with a statistical significance ($0 < 0.05$). At the other frequencies there were scarcely changes.

Fig. 2. Effect of whole-body vibration of 10 Hz on electrogastrogram (A) and its power spectrum (B) in a healthy man

Table 1. Effect of whole-body vibration exposure on EGG

	Control	10 Hz		20 Hz		40 Hz	
		During	After	During	After	During	After
Dominant frequency (cpm)	3.3 (0.7)	3.9 (1.4)	3.1 (0.4)	3.1 (0.4)	3.9 (1.0)	3.9 (1.1)	3.7 (1.1)
Relative power (%)							
Slow wave	56.6	45.8	61.7	57.7	55.9	56.6	57.3
2–5 cpm	(13.9)	(8.5)	(8.5)	(12.7)	(11.5)	(8.0)	(8.0)
Tachygastria	29.5	39.1	25.7	31.4	31.5	28.9	29.0
5–9 cpm	(12.1)	(4.4)	(3.5)	(11.7)	(11.7)	(7.4)	(8.9)

Mean (S.D.).

Discussion

Application of cutaneous EGG, noninvasive method has been limited until 1980s because of difficulty in data acquisition and interpreting EGG data¹¹⁾. However, the information about the correlation between the EGG and gastric motility has been rapidly increased by the progression of computing supported technology. The validity of the cutaneous EGG is reliable for the measurement of the gastric slow wave^{12, 13)}. The dominant frequency of the EGG can accurately represents the frequency of the gastric motility. A relative increase of power spectral density may reflect to increase the contractile activity of the stomach. For concerning the gastric dysrhythmias, tachygastria, fast wave component (5–9 cpm), was interpreted to be abnormal at nausea or vomiting^{7, 9)}.

The major result in our study was that the relative power spectral density of the slow wave (2–5 cpm) decreased significantly as compared to the value of the control by 10 Hz of WBV. This findings suggest that short-term WBV exposure can suppress the gastric motility. In the evaluation of human responses to WBV, the resonance frequency should be considered because the biodynamic transmissions of vibration depend on this factor. In particular, the knowledge of the resonance frequency of the human body to WBV is the most important for evaluating the physiological and pathological reactions. According to the observation of the human by Dupuis and Zerlett¹⁴⁾, the internal organs movement increased at vibration frequencies of 3–5 Hz and 7–10 Hz. They assumed that there was considerable strain in the tissues. These findings suggest that the passive gastric movement by vibration exposure may be maximum at 10 Hz comparing with exposure of 20 or 40 Hz. However, the relationship between the gastric movement induced by WBV and the

gastric motility in the EGG was still unknown.

In case of more longer term of WBV exposure for 1 hr, Kjellberg and Wikström⁶⁾ observed a transient increase of relative power in the frequencies of 3, 5.4 and 7.8 cpm. They concluded that the gastric motility can be affected by WBV in certain frequency ranges. We observed an opposite response in the relative power of 3 cpm in our unpublished data. This discrepancy may depend on the difference of vibration frequency, amplitude and duration of exposure. In addition, they carried out their experiments under the condition of no control of meal and fasting time. In our observation, food intake and fasting time were very important factors influencing the power spectral density of EGG. Some investigators have mentioned that taking a meal induces an increase of power in the slow wave (major frequency of about 3 cpm) in EGG^{12, 15)}.

Epidemiological study on long-term WBV exposure have revealed that high prevalence of gastrointestinal symptoms among occupations with WBV exposure have been reported^{4, 5)}. However, definite evidence of dose-effect relationship and the mechanism of this impairments have not been clarified. In the patients with gastric neurosis and non-ulcer dyspepsia, decreased power of slow wave component after test meal was observed in EGG measurement^{7, 11)}. The acute effect of WBV on the gastric motility in this study would show the suppression of the contractile activity. This suppression may have probability of leading to the gastrointestinal disorder. In conclusion, short-term exposure to whole-body vibration can decrease contractile activity of the gastric motility.

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