Gastric electrical activity and cardiovascular risk factors in relation to autonomic nervous function, hormonal responses, and health-related lifestyles in young men

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Background. Electrogastrography (EGG) is the noninvasive recording of gastric myoelectrical activity. The purpose of the present study was to assess associations of EGG with risk factors for cardiovascular disease (CVD), autonomic nervous function, hormonal responses, and health-related lifestyles. Methods. EGG was measured in 435 Japanese men, aged 24–39 years, who worked at the same company. In addition to anthropometric measurements and blood examinations, power spectral analysis of heart rate variability in low-frequency (LF; 0.04–0.15 Hz) and high-frequency (HF; 0.15–0.40 Hz) bands was conducted. LF/HF and HF were used as the indicators of sympathetic and parasympathetic nervous activity, respectively. Serum cortisol and catecholamine levels were measured as well. Results. In univariate analyses, the EGG frequency was associated positively with the serum high-density lipoprotein (HDL) and cholesterol level (both \( P < 0.0001 \)) and negatively with age, body mass index (BMI), serum triglyceride level, fasting blood sugar, and diastolic blood pressure (all \( P < 0.05 \)). The EGG frequency tended to increase with increases in the HF band (\( P = 0.10 \)) and was not significantly associated with the LF/HF ratio (\( P = 0.45 \)). Neither hormonal responses nor health-related lifestyle factors such as smoking and alcohol were significant (all \( P > 0.05 \)). A multivariate analysis indicated that both the HDL cholesterol level and BMI were independent predictors of EGG frequency (both \( P < 0.05 \)), after adjusting for the significant effects of age, HF, and other CVD factors. Conclusions. Slowed EGG frequency appeared to be linked with various CVD risk factors, including obesity and low HDL cholesterol levels, in young men.

Key words: electrogastrography, heart rate variability, high-density lipoprotein, obesity
Methods

Study setting and subjects

The study was conducted by an information services company located in the central region of Tokyo, Japan. The company offers information technology consultation, systems integration solutions, and data management. All analyses were performed during a regular employer-sponsored health-screening program mandated by the Japanese Industrial Safety and Health Law and conducted under contract by the clinical staff of a medical services company.\textsuperscript{15}

A total of 435 men aged 40 years or younger (range, 24–39 years) who reported no regular medication were recruited for the study. None had been previously diagnosed with functional dyspepsia or visited the clinic because of hypertension, hyperlipidemia, diabetes mellitus, or obesity. Those aged over 40 years were referred to an independent health examination center outside the company. Female workers were excluded from the analysis because of the small sample size and hormonal effects of the menstrual cycle on autonomic nervous function. The investigation conformed to the principles outlined in the Declaration of Helsinki, and the procedures were approved by the company’s Committee of Labor and Safety and the Teikyo University School of Medicine Ethics Committee. All of the subjects provided their written informed consent to participate in the study.

Heart rate variability

The subjects were instructed to refrain from breakfast, coffee, and smoking on the morning of the health screening so that the most accurate possible data could be obtained. All measurements were performed between 8:30 and 11:30 a.m. in an air-conditioned (25°C) environment and after the subjects had rested for at least 5 min. During the recording, the subjects were required to lie quietly in a supine position and breathe normally.

Screening for heart disease was performed by electrocardiography, and the R–R interval data acquired over a 5-min period were stored on a personal computer. To obtain stable data, only the R–R intervals over the last 1 min were used for the analysis. Power spectral analysis using the maximum entropy method\textsuperscript{16,17} was applied to the time-series data of heart rate variability. Although fast Fourier transform and autoregressive methods have been widely used for spectral analysis, these have some limitations, including poor resolution attributable to the effect of the window functions and the short lag time. The maximum entropy method was used to overcome these limitations and to provide a high degree of resolution despite the limited duration of data collection.\textsuperscript{18}

Low-frequency (LF; 0.04–0.15 Hz) and high-frequency (HF; 0.15–0.40 Hz) bands were used in the study. The LF/HF ratio was assumed to reflect sympathetic nervous activity, and the HF band was assumed to reflect parasympathetic nervous activity.\textsuperscript{16,19,20}

EGG

Three standard Ag/AgCl disposable electrodes (Nihon-Koden, Tokyo, Japan) were attached to the abdominal skin surface after skin preparation.\textsuperscript{21} Bipolar active electrodes were attached to the skin surface horizontally across the upper abdomen. The third electrode was used as the reference lead and was placed midway between the two active electrodes and the umbilicus. The EGG signals were measured with an automatic waveform analyzer, which consisted of an analog-to-digital converter and amplifier and filter modules (MP150A-CE; Biopac Systems, Tokyo, Japan). The recording frequency cutoffs were set at 2.1 and 5.4 cycles per minute (cpm), and digital recording (16 bit) occurred at the rate of 100 samples per minute for 10 min.\textsuperscript{22} Because of the nature of routine health examinations, it was difficult to measure the EGG signals for a longer period, and these 10-min EGG measurements were performed while keeping the subjects in a supine position after enough rest, including 5 min of rest and 5 min during which heart rate variability was measured. The acquired data were downloaded to a personal computer and analyzed by using AcqKnowledge for Windows (Biopac Systems). All EGG measurements were recorded by a single trained researcher who worked independently of the study.

CVD risk factors

Based on criteria from previous studies,\textsuperscript{11,12,22} the following CVD risk factors were assessed: age, body mass index (BMI), serum triglyceride level, serum high-density lipoprotein (HDL) cholesterol level, fasting blood sugar, and blood pressure. In addition to these traditional CVD risk factors, plasma catecholamine (adrenaline, noradrenaline, and dopamine) and cortisol levels were assessed. Because the study was conducted in the setting of a routine health examination, a blood catheter was not used to measure plasma catecholamine and cortisol levels. Instead, blood was directly taken from the cubital vein after 15 min of supine rest. Serum triglyceride, HDL cholesterol, and fasting blood sugar levels were measured by standard laboratory techniques. After centrifugation at 1500 g for 10 min at 4°C, the supernatant volume was stored at −40°C until the assay. Plasma catecholamine was measured by routine high-performance liquid chromatography,\textsuperscript{23} and plasma cortisol was measured by radioimmunoassays.\textsuperscript{24}