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A Single Channel Electrogastrogram Frequency Domain Analysis and Correspondence to Brain Activity in a Resting State Condition

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ABSTRACT An electrogastrogram (EGG) is a well-known method to record gastric myoelectrical activity. However, some researchers believe that EGG measures the gastric slow wave and can be used as a surrogate for gastric motility, whereas others claim that EGG is flawed. Our proposed study broadens the scope of EGG research, particularly by offering the opportunity to observe gut-brain channels of communication that could enhance comprehending the characteristics of the brain and behavior in response to psychological changes. This study focuses on how to confirm single-channel EGG's setup with public datasets and previous studies and how to observe the relationship of gut-brain axis pathways. We gathered four subjects utilizing a 250 Hz bioamp to monitor head scalp brain wave activity including gastric activity and used Zenodo's EGG dataset for the confirmation phase. To examine gastric myoelectrical activity, we positioned single-channel electrodes around the stomach. Then, we used a particular band-pass filter to retrieve the EGG's power spectrum (0.03 – 0.07 Hz). We extracted the EGG's power spectrum and prevalent frequency as primary features. Concerning brain electricity activities, we used the FIR filter to acquire each brain wave's properties. We discovered that separate subjects had different responses during pre- and postprandial, both from primary and secondary resources. We found that the increase in EGG activity drove a change in EEG characteristics, notably in the alpha band (8-12 Hz). Moreover, the EEG P3 electrode site in the parietal lobe followed the power change rates of the EGG between 0 to 0.015 of relative power. We conclude that P3 and slow-wave gastric movement from EGG correspond to each other and reflect gut-brain axis pathways. However, future studies with larger samples must strengthen our findings according to the gut-brain axis pathways in the P3 site and EGG.

INDEX TERMS EEG, EGG, gut-brain axis, brain waves.

I. INTRODUCTION

The widely used Electrogastrogram (EGG) technique uses cutaneous electrodes applied to the skin of the abdomen above the stomach to record the myoelectric activity of the stomach. Given that EGG is a non-invasive technique, it has drawn a lot of interest from researchers and medical professionals. On the other hand, some researchers contend that EGG is faulty and that it assesses the stomach slow wave, which can serve as a stand-in for gastric motility [2]. Conversely, clinical research in gastroenterology views EGG as a clinical tool for comprehending anomalies in stomach rhythm and psychophysiology [2–4]. Owing to the EGG's minuscule electrical signal and its vulnerability to interference from external signals, numerous signal processing methods and EGG installation procedures have been effectively

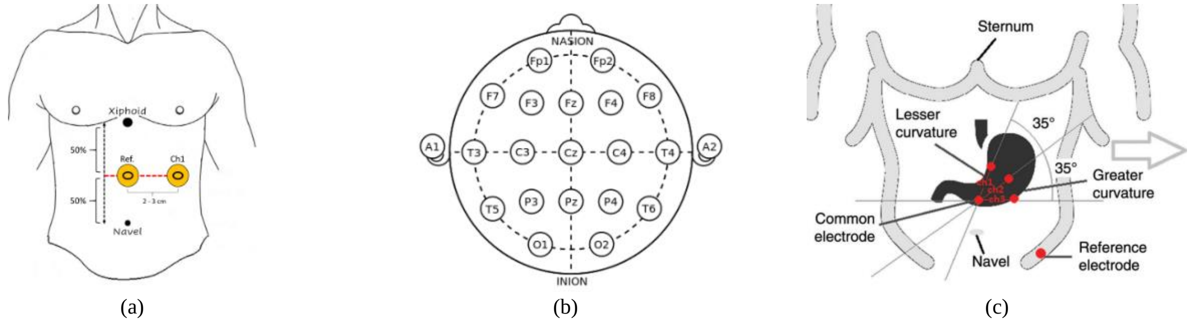

FIGURE 1. EGG, EEG placement configuration of proposed system (a, b) and reference (c [9])

documented in recent studies. By utilizing an adaptive filter and sensor array, these methods seek to produce precise and trustworthy data [1, 2, 5]. Various studies employing EGG as a clinical and diagnosis tool have also been reported to diagnose gastric motility disorders and tools for clinical applications [16, 17]. The challenge continues; since the establishment of EGG's procedure still utilizes multi-channel configuration to obtain better signal quality, it is easy to set up EGG as a wearable and daily device with a single-channel configuration. Therefore, a simple installation is needed for further development, and the need for a simple installation with a single channel became more interesting in EGG's studies. The latest development of single-channel EGG is limited. It was reported that a simple single-channel setup successfully separated the differentiation between before and after meals. Surprisingly, according to the Body Mass Index, it can affect the location and quality of single-channel EGG's retrieval process [15].

Thus, we think that expanding EGG research could provide fresh perspectives on how to use it. The conceivable significance of visual signals in comprehending the brain and behavior for feelings, self-consciousness, and physical and mental health has been brought to light by psychophysiology [6–8]. Also, the paths of gut-brain communication mechanisms that indicate the interchange of sensory transduction between abdomen food intakes and the brain can enhance the understanding of the precise condition or behavior anomalies conceivably yielded by gastric motility. Then, EGG development is urgently required to study diet behavior, allergies, and other gastroenterology cases that resemble brain properties.

We proposed this examination as an initial study to assess whether the pre- (fasting) and postprandial states on a single EGG influence brain attributes change. Then, we would like to answer the following question: Which part of the brain and brain waves tend to correlate between brain and gastric movement before and after a meal? Nevertheless, first, we must confirm whether our EGG's configuration is acceptable compared to previous investigations with identical setups and references (single-channel utilization). By obtaining information on how the brain and slow-wave gastric interact during pre- (fasting) and postprandial, we could observe several manifestations and behaviors suspected of coming from meal intake or additional digestion irregularities as an outcome of the gut-brain connection mechanisms. Then, by demonstrating the short-term frequency domain analysis, we hypothesized that gastric myoelectrical movement depicting gastric motility could affect the brain wave features.

Our proposed study consisted of several phases. Before we evaluate the connection of the brain-gut axis, we clarify the setup of single-channel placement between ours and previous studies to confirm the occurrence of power dominance in 0.03 - 0.07 Hz of frequency. Then, we applied inter-subject analysis to observe the consistency between subjects during pre- (fasting) and post-prandial. Finally, we employ a short-time Fourier transform to evaluate the correlation over time between brain waves and slow-wave gastric movements during two conditions. Visual inspection during inter-subject analysis is compulsory when performing spectrogram analysis.

II. RESEARCH METHODS

A. ETHICAL CONSIDERATION

Our proposed study fulfilled the ethical policies related to human experimentation, as outlined in the Declaration of Helsinki. Since we are concerned about the ethical clearance of this study, the experimental design was already approved by the ethical committee of the medical faculty of Universitas Islam Indonesia Yogyakarta No. 19 / Ka.Kom.Et / 70 / KE / VIII / 2024. Before the experiment, we explained the experimental procedure, including the prohibition matters that need to be avoided by participants before the day of the data retrieval. If the participants declined or could not follow the procedure, we excluded them from the dataset. Then, we obtained the subjects' informed consent before the experiment.

B. DATA COLLECTION

We collected the primary dataset from university students. Four male subjects working at a university participated in this study to ensure a uniform environment. Their ages were between 22 and 30 years old. We ensured that the participants understood and confirmed their health conditions before the experiments, without the need for any medication. The subjects were also healthy and did not experience any brain, respiratory, or cardiovascular diseases. We ensured the subjects slept enough before and during the experiment (pre-treatment) to avoid any different outcomes. We excluded any subjects that did not meet the criteria.

To validate the electrogastrogram data and feature extractions from ours, the secondary dataset was also collected from Zenodo; a public dataset was provided to twenty subjects (age: 25 ± 2.66 years old, height: 179.10 ± 11.73 cm, weight: 77.90 ± 16.58 kg) during fasting and postprandial conditions. The data were obtained using an A/D card with a 2 Hz sampling rate and a procedure similar to the one we had already proposed. All signals were filtered with a third-order band-pass Butterworth Filter with cut-off frequencies of 0.03 Hz and 0.25 Hz [9].

As mentioned, this study conducts analyses using primary and secondary datasets. Following the same steps as [10], we obtained information from first-hand and second-hand sources to examine how consistent a single-channel electrogastrogram was in different settings. Second, we recorded the participant's brain activity using an international 10–20 electrode placement system on 19 sites on their scalp to provide a relationship between the gut and the participant's gastric myoelectrical data using poly-channels from the brain activity recorder according to FIGURE 1 placement system.

C. RECORDING EQUIPMENT

We collected the slow wave gastric movement to quantify the digestion process of this study utilizing a biopotential amplifier (bioamp), MITSAR EEG. We demonstrated a single-channel electrogastrogram using the amplifier's poly-channel and position already depicted in FIGURE 1 (a). The low pass cutoff frequency was 50 Hz, and the sampling frequency was 250 Hz. To understand brain activities and help out the gut-brain axis intention, we employed a 10–20 international electrode placement technique where 19 electrodes were positioned on the head scalp (FIGURE 1(b)). The brain electrodes' impedance ought to be lower than 10 kOhm. We referenced our recorded data of the stomach myoelectrical activity using a single-channel bipolar electrode, as configured in FIGURE 1 (c) reference. Before the feature extraction step, we applied a 50 Hz notch filter based on Eq. (1) to eliminate and ensure powerline interference at 50–60 Hz had already diminished [27].

$$H(s) = \frac{s^2}{s^2 + \frac{w_0}{Q} + w_0^2} \quad (1)$$

Where H_s is the transfer function in the Laplace domain, ω_0 is the center frequency of the notch and Q is the quality factor.

D. EXPERIMENTAL DESIGN

This study's main aim is to observe the changes in the gastric slow-wave movements corresponding to the brain wave activity during pre- (fasting) and postprandial. Four subjects' data were recorded following previous studies' recommendations using a single-channel electrogastrogram electrode [10]. The experiment was conducted in two sessions. Subjects must sit straight, relax, and awake during the sessions. For the primary datasets, in the first phase, the participants sat for ten minutes (pre-prandial/fasting). Before the second session, participants were asked to eat a snack or means and drink water until they felt full enough (postprandial). Shortly afterwards, subjects must sit straight

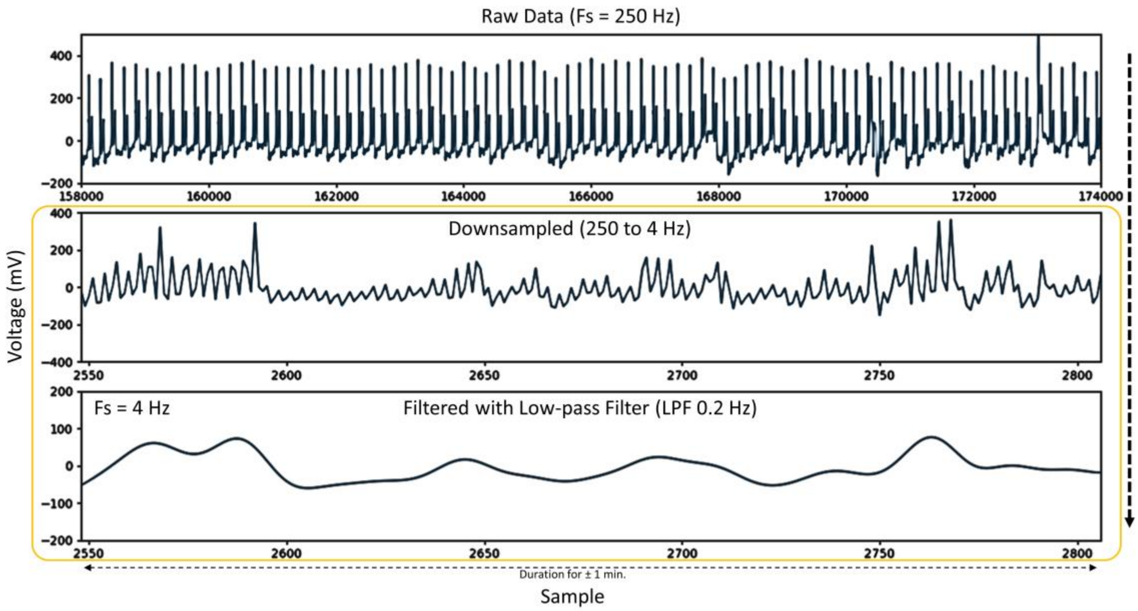

FIGURE 2. EGG's signal processing to under-sampling 250 Hz to 4 Hz

and relax for the second recording session for the next twenty minutes

E. SIGNAL PRE- POST-PROCESSING AND FEATURES EXTRACTION

Regarding our primary dataset, this study exhibited two types of physiological signal processing: brain activities using EEG and digestive slow gastric movements of EGG signal processing. We utilized the acquired raw data for the further step of EGG's signal processing and feature extraction, while EEG needs to apply the FIR band-pass filter (Eq. (2)) between 1-40 Hz before it decomposes into prominent brain waves [27].

$$h(n) = \begin{cases} \dfrac{\Omega_H - \Omega_L, for\ n = 0}{\dfrac{\sin(\Omega_H n)}{n\pi} - \dfrac{\sin(\Omega_L n)}{n\pi}, for\ n \neq 0} \end{cases} \quad (2)$$

The $h(n)$ represent the impulse response of the filter at time index n, Ω_H, Ω_L are the cut-off between the high and low frequencies, respectively. The purpose of both EEG and EGG signal processing is to extract the features in the time-frequency (spectrogram) and frequency domain. The time-frequency domain features were extracted using the Short-Time Fourier Transform (STFT), and we used the Fast Fourier Transform (FFT) to decompose frequency components from the recorded data, as depicted in Eq. (3) [28].

$$\mathrm{X}[\mathrm{k}, \mathrm{n}_0] = \sum_{\mathrm{n}=0}^{\mathrm{N_{FT}}-1} \mathrm{x}[\mathrm{n}_0 + \mathrm{n}] . \mathrm{w}[\mathrm{n}] . \mathrm{e}^{-\mathrm{j}\frac{2\pi \mathrm{kn}}{\mathrm{N_{FT}}}} \quad (3)$$

$X[k, n_0]$ is the presentation of frequency magnitude at k time frame index, $x[n_0]$ and x are the signal, $w[n]$ the window hamming function presented in Eq. (4), and $e^{-j2\pi kn/N_{FT}}$ represent the complex exponential used in the DFT [28].

$$w[n] = 0.54 + 0.46cos\frac{\pi n}{M}, -M \leq n \leq M \quad (4)$$

We employed the Finite Impulse Response (FIR) band-pass filter between 1–40 Hz as a pre-processing phase (pre-processed data) into recorded EEG data to avoid the DC offset and powerline interference. We extracted the major brain waves (delta, theta, alpha, and beta) from each subject's EEG data using Fourier Transform (Eq. (5)) [28].

$$X[n] = \frac{1}{N}\sum_{k=0}^{N-1} x[k]e^{-j2\pi\frac{k}{N}} \quad (5)$$

Eq. (5) is the basis of Fourier transform where x[k] is the Fourier of the sequence X[n], and N the total data with k represent the frequency index. The time-frequency decomposition method extracts the brain waves (delta (1–4 Hz), theta (4–7 Hz), alpha (8–12 Hz), and beta (13–30 Hz)) for every one-minute window with 20% overlap. We demonstrate the power of per window segment on each brain wave for additional analysis based on Eq (6) and (7). P_{rel} is the relative power that acquired by quantifying the sum frequency power of i in domain frequency over the total power from Eq.(5) and the $AvgP_{rel}$ is the average of selected relative of $P_{rel}(BP)$ [29].

$$P_{rel}(BP) = \sum_{i=1}^{N} \frac{BP(i)}{TP} \quad (6)$$

$$AvgP_{rel} = \frac{1}{N}\sum_{i=1}^{N} P_{rel}(i) \quad (7)$$

A low sampling frequency is already known and needs to be treated with a low sampling frequency [1]. Based on our proposed method that used a high sampling frequency, such as the EEG sampling properties, the following signal processing technique is mandatory before assessing the EGG frequency component (FIGURE 2).

- Step 1: Normalized detrended pre-processed signals from the baseline of recorded EGG data.
- Step 2: The detrended data got down sampled to 4 Hz using Eq. (8) [28].

$$y[n] = x[Mn] \quad (8)$$

  Where x, M are the original signals with down sample scale, respectively.
- Step 3: To reduce the number of filter orders, apply a 0.2 Hz low-pass filter to the down-sampled data using a butter-worth filter type.
- Step 4: By using STFT with a one-minute window with 20% overlapping, we extracted the frequency component from the previous filtered data.
- Step 5: Accumulate the power of EGG properties between 0.03–0.07 Hz on each one-minute window segment.

After the power of each EEG and EGG electrode was extracted, we examined and compared the power between brain waves from nineteen electrodes corresponding to the EGG per segment to investigate the differences and other effects of both signals during pre- and postprandial. We also demonstrated the same procedure of EGG features extraction to the secondary data from Zenodo to validate our proposed method. Then, we confirmed whether the features were valid for retrieving slow-wave gastric movement information.

F. DATA ANALYSIS

To validate our EGG biosignal processing, we evaluate our data from four participants compared to twenty subjects from Zenodo's database to ensure the procedure can produce identical results. Since the amount of data from our four primary subjects, we realized that this study avoided performing an inference statistical analysis. However, this study concentrated on inter-subject analysis. After extracting the features of brain waves and gastric myoelectrical movement, this study analyzed both biosignals using time-frequency analysis. We computed the Pearson correlation according to Eq. (9) function to measure the potency of strength between EEG and EGG parameters during pre and postprandial from one-minute window segments to evaluate the relationship between brain and gastric myoelectrical properties (x, y) with r as the Pearson correlation coefficient followed by are the brain and slow-wave gastric parameter respectively at i − data [30].

$$r = \frac{\sum(x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum(x_i - \overline{x})^2 - (y_i - \overline{y})^2}} \quad (9)$$

III. RESULTS

A. EGG AND EEG PROPERTIES DURING PRE- (FASTING) AND POSTPRANDIAL

Our primary dataset (four subjects) revealed changes in gastric slow movement during pre- (fasting) and postprandial periods. Based on our investigation, FIGURE 3(a) revealed that among the four participating subjects, S1 and S2 experienced an increase in relative power (0.03–0.07 Hz) during the postprandial period, while S3 and S4 remained unchanged or slightly higher during preprandial instead post. In General, the power spectrum of gastric slow-wave movement during pre- and postprandial was less than 0.1. The distinction in frequency between 0.03 and 0.07 Hz before and after the abdomen intake is already believed to be strongly connected to stomach movement. The frequency attribute to the corresponding frequency range tends to rise along with the time changes, mainly at 0.05 Hz (FIGURE 3(b)). Moreover, the relative power in the identical frequency range also shows heightened activity while recording the whole postprandial condition.

On the other hand, the secondary database shows that fifty percent of the subjects (ten subjects) had the same properties as our experimental data, where the EGG's postprandial

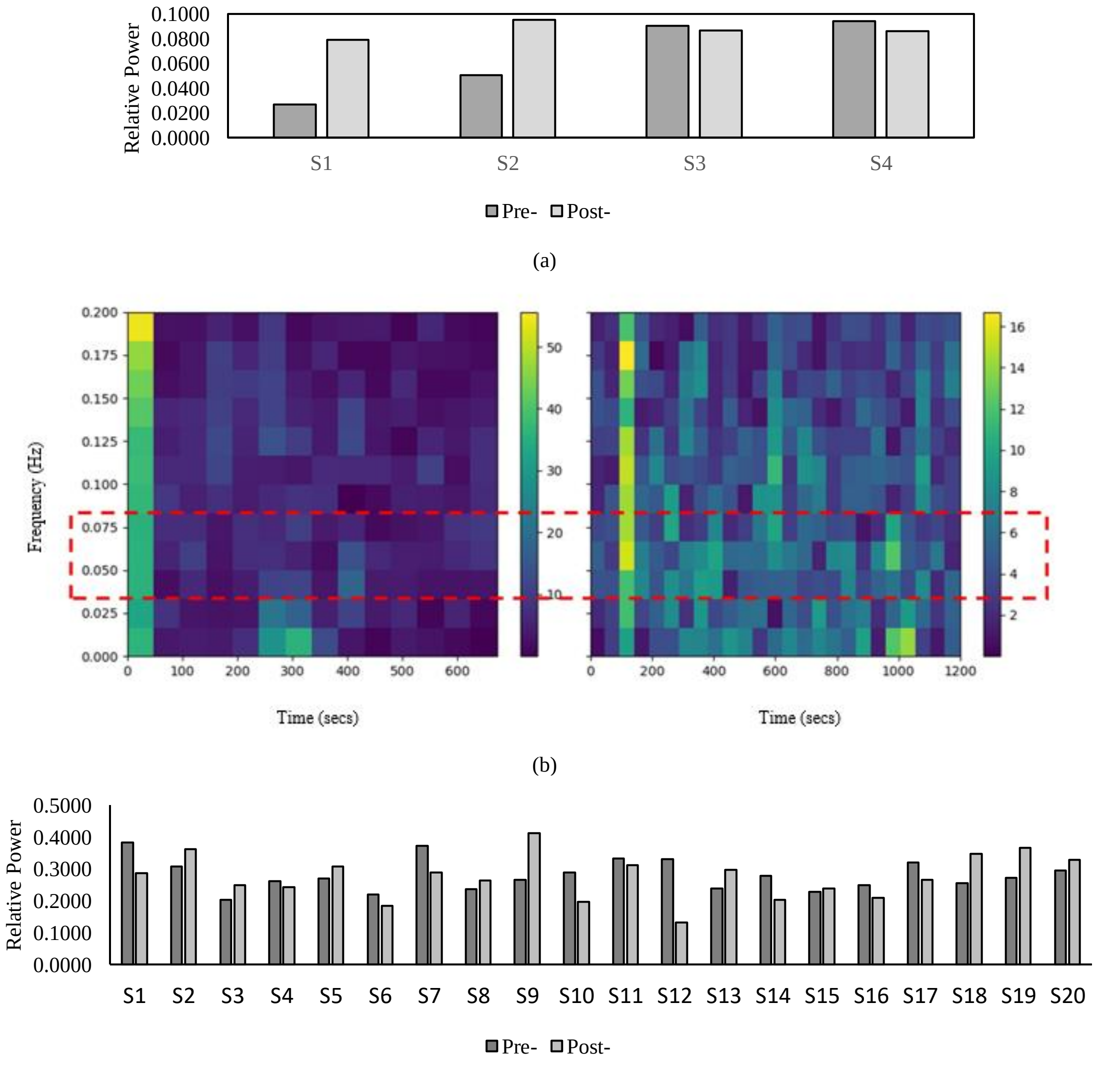

FIGURE 3. **Pre- (fasting) and postprandial properties between primary (a, b) and secondary database (c)**

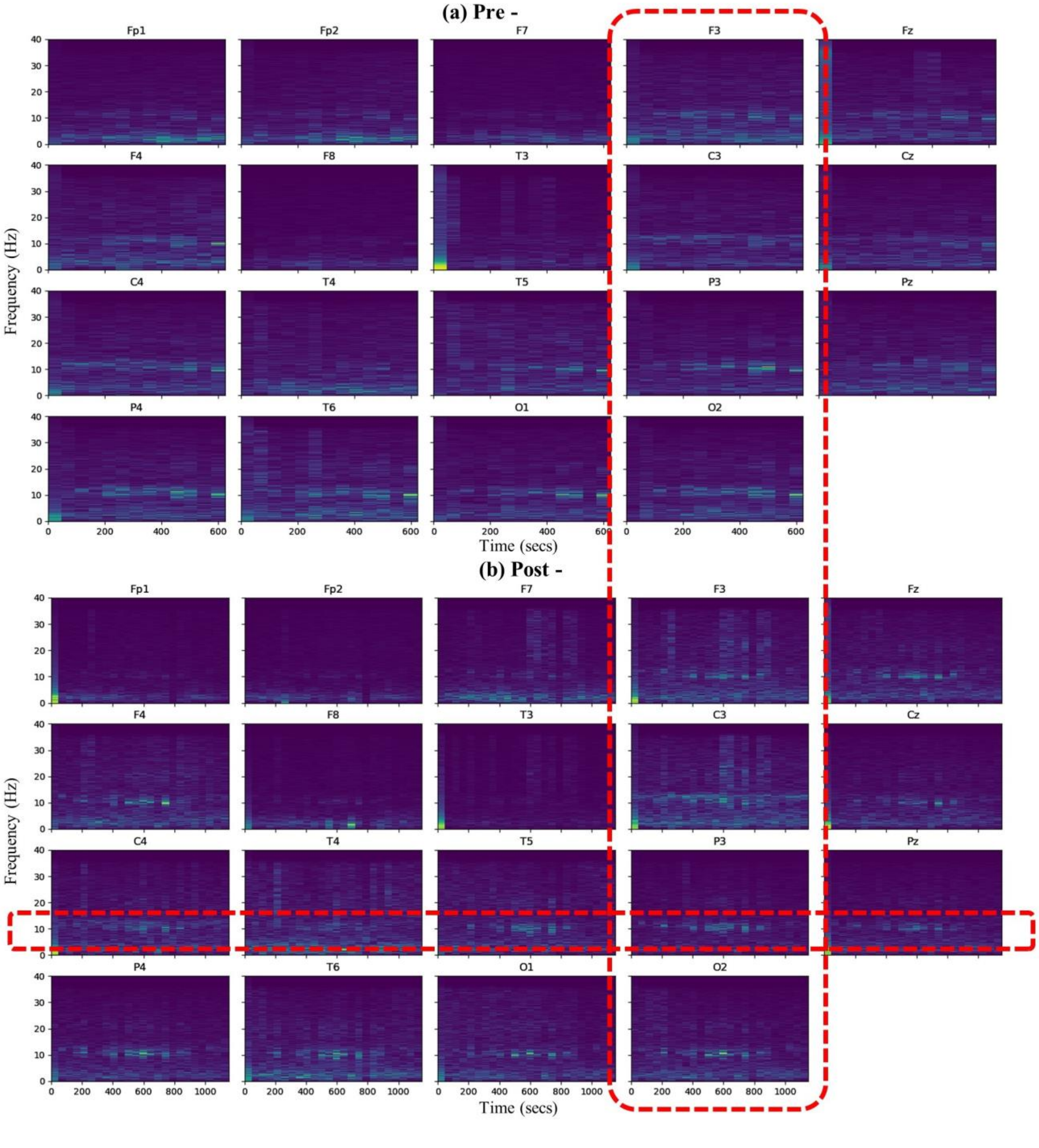

FIGURE 4. EEG's relative power during pre-(fasting) (a) and postprandial properties (b)

relative power tends to be higher than the pre-prandial (fasting) relative power. The other ten subjects show that the pre-prandial (fasting) relative power is higher. Interestingly, the primary dataset also displays a similar pattern, with 50% of the total data showing an opposite trend (FIGURE 3(c)). This evidence confirmed that our experimental design had equivalent attributes to another investigation with a single channel of electrogastrogram.

FIGURE 4 shows that brain activities also change during pre-(fasting) and postprandial conditions, especially in the frontal, central, and parietal areas. This finding confirmed that brain-gut properties can be observed using electrophysiological signals from EEG and EGG. The occurrence of a higher power in brain activities is probably connected to the electrogastrogram as a digestive system pathway.

TABLE 1
The Pearson correlation between EGG's specific rel. power (0.03 – 0.07 Hz) and EEG's alpha over total power

	S1		S4	
	fasting	**postprandial**	**fasting**	**postprandial**
Fp1	–0.41	0.24	0.28	–0.09
Fp2	–0.38	–0.04	0.27	–0.04
F7	–0.56	0.46	0.25	–0.08
F3	–0.30	0.45	0.23	–0.10
Fz	0.41	0.45	0.18	–0.09
F4	–0.32	0.40	0.22	–0.07
F8	–0.47	0.34	0.20	–0.01
T3	0.92	0.46	0.15	–0.07
C3	–0.10	0.44	0.25	–0.12
Cz	–0.14	0.44	0.26	–0.09
C4	–0.27	0.38	0.16	–0.10
T4	–0.38	0.34	0.28	–0.09
T5	–0.36	0.39	0.11	–0.01
P3	–0.35	0.38	0.16	–0.08
Pz	–0.35	0.36	0.39	–0.11
P4	–0.26	0.33	0.13	–0.02
T6	–0.25	0.44	0.08	0.05
O1	–0.33	0.39	0.10	–0.03
O2	–0.42	0.38	0.12	–0.07

B. RELATIONS BETWEEN BRAIN AND SLOW-WAVE GASTRIC MYOELECTRICAL ACTIVITY

Since the secondary dataset only records EGG properties, our proposed study, using the primary dataset, successfully observed changes in brain waves and gastric myoelectrical activity on both time-frequency and frequency domain characteristics during pre- and postprandial periods. Despite the contrasting behavior of those biosignals, we posited that the distinctions between brain waves and gastric myoelectrical activity offered significant insights into the interaction itself. We took out the relative power of EGG from 0.03 to 0.07 Hz and five EEG major brain waves, delta, theta, alpha, and beta, over a minute to examine how the activity in the stomach relates to activity in the brain. We utilized S1 and S4 to conduct a thorough analysis, as they provided representative examples of the relationship between brain activity and gastric movement, which aligned with our proposed research. TABLE 1 shows the correlation coefficients between EGG power (0.03–0.05 Hz) and EEG alpha-band power (8–12 Hz). On subject S1, the pre-prandial (fasting) trend is opposite from positive correlations, while the postprandial trend has a positive direction. Conversely, on subject S4, the pre-prandial (fasting) exhibits positive correlations, as opposed to the postprandial. These effects portray the power change rates of both EGG and EEG, respectively.

Another critical finding is understanding how the brain interacts with the electrogastrogram during pre- and postprandial periods through analysis of secondary datasets. Based on the investigation of the four subjects, we discovered that the power spectrum properties of EGG (0.03–0.07 Hz) and EEG (alpha, 8–12 Hz) represented the opposite tendency. We also proposed our developed parameter, the power change rates of EGG and EEG before and after meals according to Eq. (10).

$$P_{change-rates} = \frac{P_{post} - P_{pre}}{P_{pre}} \quad (10)$$

The inter-subject examination revealed that the parietal lobe (P3) produced the most immediate trend with EGG properties than the other EEG channels (FIGURE 5). Given that the parietal lobe governs sensations such as touch, pressure, taste, and body awareness, we believe that we can observe the interplay between brain wave and gastric myoelectrical activity to depict gut-brain signaling. This interaction can illuminate various aspects of gut-brain signaling and other psychophysiological aspects [13, 14]. Previous studies that explore the response of brain characteristics to gastric slow-wave movements, particularly those that directly observe brain behavior during pre- and postprandial periods, have been limited in scope. Despite some flaws claimed by other researchers, our study found that the interaction between the gut and brain can be observed non-invasively using conduction time-frequency analysis. Proper profiling tools or subjective evaluations are compulsory for further investigation to validate the interaction between those two biosignals. Finally, this finding should attract more awareness to perform similar studies, especially to explore the human brain influenced by food intake, diet, gastric abnormalities, and psychological changes.

IV. DISCUSSION

This study successfully answered problems that were being formulated in the beginning. Firstly, single-channel EGG can be developed to minimize setup time. Compared with the secondary sources, our proposed studies elicit identical results: most subjects provide a higher power spectrum after meals. We successfully confirmed from two resources (primary and secondary datasets) that half of the total subjects' gastric myoelectrical activity is higher postprandially than pre-prandial (fasting) [2]. Therefore, a single channel can be utilized for further study to simplify the process, which often takes thirty to one hour for the preparation phase [2, 15, 18, 19]. Since we were not conducting any subjective evaluation, this study could not verify the causality of the discrepancies from a psychological point of view. However, since all subjects are treated similarly, preferences and behaviors associated with specific foods could be the one intent of subjects' disparities. Previous studies reported that food preferences, indeed, gastric activities, secretion, and overall digestive processes. For instance, high-fat foods, high-sugar

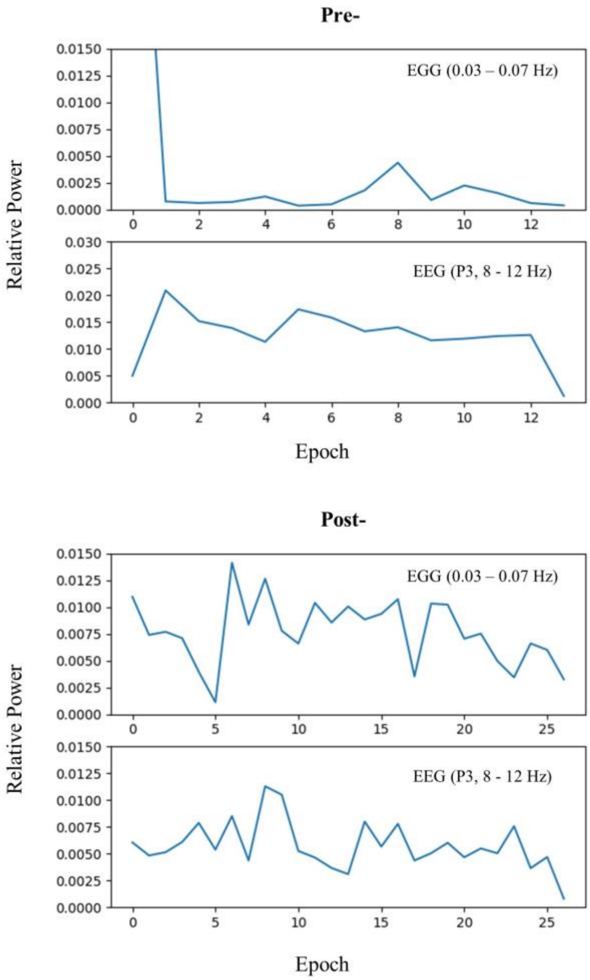

FIGURE 5. Pre- (fasting) and postprandial properties with the closest trend between EGG properties and egg p3 site

foods, fiber-rich foods, and Individuals' preferences for certain types of food can also impact their overall digestive health and eating patterns, affecting gastric function [20-22]. We confirmed that from both sources, the disparities could be the effect of our findings as well. On the other hand, the other participants exhibited different gastric myoelectrical activity. Based on secondary database resources, the same manners were observed in the ten subjects of twenty participants. According to previous cases, this could be related to the abnormal or subjective electrogastrogram affected by several aspects [11, 12].

Another important finding related to the gut-brain axis. Our findings found that the left parietal (P3) had some potential with EGG power changes over time. As we already mentioned, compared to the other brain sites, P3 could be related to governs sensations such as touch, pressure, taste, and body awareness; we can observe the interplay between brain waves and gastric myoelectrical activity to depict gut-brain signaling. Interestingly, we confirmed that the P3 site in the brain lobes, also known as the posterior third ventricle, plays a significant role in regulating gastric motility through the gut-brain axis. This area involves the neural pathways that control digestive functions, including gastric secretion and motility. The brain communicates with the gut via these pathways, allowing for continuous feedback and regulation of digestive processes [23].

To compare our study to the most recent finding during the utilization of gut-brain axis interaction, we found that the study of gut-brain coupling still needs to be adjusted as a standard procedure in clinical application. A recent study reported that the gut-brain axis can monitor the brain-gut activity during the intervention in Parkinson's Disease (PD) patients. The relation between gastric activities and PD's Dyskinesia score mediated in centro-parietal beta power [24]. According to our findings, the brain location near the parietal can be observed as an abnormal interaction as a brain-gut interaction, and the idea of measuring the interaction between the brain and digestive activity is confirmed and possible as well. Another study also revealed that the gut-brain axis computer interfacing (GBCI) can predict emotional state after biofeedback training. However, their study investigated how the GBCI can detect emotional changes during intervention and, where possible, not engage during the stimulation [25]. Compared to our proposed study, the gamma band should be the main focus of brain activity during the intervention compared to our study in resting state conditions (alpha and beta power). In addition, the artifacts during active conditions also reduce the quality of EEG and EGG signals, and we avoid it by demonstrating resting state conditions.

However, the current studies employ the Gut Microbiota to represent brain activity as the reflection of gut-brain axis interaction. The previous research initiated our study, and the mechanism of functional gut disorders remains to be clarified; previous data studies suggest evidence that the brain-gut axis significantly affects gastrointestinal motility. The primary role of endoscopy in diagnosing functional gastrointestinal disorders is to exclude organic gastrointestinal disorders. The esophagus's lower esophageal sphincter and a gamma-aminobutyric acid B mechanism play essential roles in gastroesophageal reflux disease. In the stomach, corticotropin-releasing factor, neuropeptide Y, and other substances might be involved in the pathogenesis of non-ulcer dyspepsia. In the small intestine, corticotropin-releasing factor, gamma-aminobutyric acid B, and other substances are considered to modulate intestinal transit via central mechanisms. In the colon, it is known that psychiatric factors are related to the onset and clinical course of irritable bowel syndrome. Serotonin, corticotropin-releasing factor, gamma-aminobutyric acid, orphanin FQ, and neuropeptide Y have been reported as putative neurotransmitters. More efforts in basic science studies and animal and human studies of gastrointestinal tract physiology are still required [26]. Therefore, studies utilizing brain activities based on EEG measurement and gastric slow wave motility using EGG still need to be completed.

Weaknesses and limitations are not vulnerable in our proposed study. We realized that we could not conduct this study in a large population due to ethical considerations and time limitations of our study. Our research needs to clarify several aspects, such as the subjects' specific medical history and food behavior due to gastrointestinal characteristics. We also need to stimulate several food intakes (post-prandial) to enrich our findings. However, we must consider the time differences before and after meals to strengthen the effect of gastric slow wave changes. Our proposed study could improve the utilization of single-channel EGG to increase efficiency. We also confirmed that the Parietal could be the promising brain site to be investigated for further gut-brain axis study.

VII. CONCLUSION

We proposed a study to investigate the possibility of observing the relationship between brain waves and gastric myoelectrical activity during pre and postprandial. We confirmed that our single-channel preparation met identical properties compared to the public database with a similar environment, that 0.03 - 0.07 elicit significant power spectrum changes during pre-(fasting) and postprandial. Specifically, the power spectrum around 0.05 Hz significantly increased after a meal. Then, we found that those biosignals' interactions can be measured using time-frequency analysis (spectrogram). The power spectrum properties of EGG (0.03–0.07 Hz) are in correlation with EEG brain waves, especially in the alpha band (8–12 Hz). The power change rate showed that the P3 site followed the trend of the EGG properties than the others. We suggested that this study needs further investigation, primarily by increasing the number of subjects with specific stimuli, especially to dig deeper into the gut-brain signaling issues. However, to validate this study, profiling tools of each subject are compulsory for the next plan.

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