Impact of Gum Chewing on Mental Health of Depressed Patients Treated in the Outpatient Clinics of Psychiatric Hospitals

Takeshi Katsuki and Kazuyo Kusaka

Objectives: Gum chewing might increase blood circulation of cerebral microvessels and might activate serotonergic neurons. We investigated the impact of gum chewing on mental health in patients with depression treated in the outpatient clinics of psychiatric hospitals. Methods: Between October, 2011 and November, 2011, 12 patients diagnosed with depression and treated regularly in the outpatient clinics of psychiatric hospitals located in rural area in Japan, were enrolled in the present study. Interventions of gum chewing for participants were approximately 3 minutes immediately after daily meal and usually 3 times per day for 7 days, following 7 days of non-intervention (control) period for taking the reference of individual mental health. All brain waves were recorded using a portable specific device with a single-channel electroencephalogram recording device. Changes in individual mental health were assessed by the 30-item general health questionnaire (GHQ-30). Results: A frequency of alpha waves significantly increased during 7 days of intervention period in each individual. Total GHQ-30 scores fluctuated during 14 days. Conclusions: According to the preliminary results in the present study, intervention of gum chewing for patients with depression may be of some roles in maintaining their mental health. Further objective assessment would be necessary to confirm the impact of gum chewing on mental health in patients with depression. (Kitakanto Med J 2013; 63: 13-20)

Key words: brain wave, day hospital, depression, gum chewing, mental health

1. Introduction

The World Health Organization reported in October 2012 that approximately 350 million people were suffering from depression. In Japan, the number of patients with depression increased from 433,000 in 1996 to 1,041,000 in 2008. Therapies for depressed patients generally consist of pharmacotherapies, psychotherapies, cognitive behavior therapies, and electroconvulsive therapy; previous studies have demonstrated the medical effectiveness of these therapies. In most cases of depression, this combination of therapies is a customary treatment.

Some studies have verified the effects of physical therapy, such as massage or aerobic training, on depression, yet it is still seen as an alternative type of therapy. Physical therapies are theorized to positively affect depression by increasing blood flow and serotonin in cerebral microvessels in the brain. Previous studies have measured serotonergic neuron activity in the brain by analyzing the amount of alpha waves visible in electroencephalography. The validities of these therapies, however, have not yet been verified.

Digestion is another kind of physical therapy expected to be effective for mental health, which has been verified by some prior studies. The subjects in these studies were not patients but healthy participants, thus the direct applicability to depressed patients is not known. Moreover, the reproducibility of digestion was not sufficient because it was hard to keep all variables uniform, such as chew quality, quantity of food eaten, and feeling to taste.

Therefore, we directed our attention to gum chewing as a suitable digestion intervention as previous studies have demonstrated a comparatively high reproducibility rate. As we could not find any studies in which gum chewing was performed as an intervention for patients with depression, we used gum chewing to evaluate the impact of digestion and its influence on the mental health of patients with depression.
In order to evaluate the effectiveness of the intervention, we used an electroencephalogram-recording device and a mental health questionnaire scale, both of which have been used extensively.\textsuperscript{12,13} Impact was measured by the variation in brain alpha waves, as well as by mental health score, because gum chewing was expected to activate alpha waves.\textsuperscript{14–16}

II. Objectives

We investigated the impact of gum chewing on mental health in patients with depression treated in an outpatient clinic of a psychiatric hospital.

III. Methods

1. Subjects

Twelve patients diagnosed with depression and treated regularly in the outpatient clinics of psychiatric hospitals located in rural area in Japan were enrolled in the present study. The 12 subjects were selected on the basis of their symptoms and mental stability levels, stemming from 25 subjects in the outpatient clinic that were originally screened. Consent prior to study initiation was obtained from all selected patients, the concerned hospitals, and the patients’ doctors.

The patients attended regular treatment programs in the outpatient clinic. These programs had weekly schedules and were free to attend. Interviews were conducted face-to-face with each patient during program break times every Saturday during the study period.

2. Study period

October-November 2011

3. Instruments/outcome measurement

A portable, single-channel electroencephalography (EEG) recording device (MRT) was used to measure alpha wave percentage in order to validate serotonin neuron activation. The portable device consisted of a set of headphones [Figure 1]: conductive material reference and ground electrodes were contained within the left ear-pad, while the active electrode was embedded in the flexible arm extending from the left headband. Sampling, amplification, filtering, and artifact reduction of the raw 128 Hz data were carried out within the embedded microchip, as were Fourier transformations, and transmitted to the display/recording application (NeuroView, NeuroSky, USA) via Bluetooth. While the active electrode was set at the front of the head, the reliability of the device to measure brain waves, including alpha waves, has been previously certified.\textsuperscript{9,12,13} The 30-item General Health Questionnaire (GHQ) was used to assess changes in individual mental health.

4. Data collection

Baseline data collected on the 1st day of the study included patient age, sex, and diagnosis. Gum chewing interventions occurred approximately 3 minutes after daily meals, 3 times per day for 7 days. This followed 7 days of a non-intervention (control) period. All brain waves were recorded using a portable single-channel electroencephalogram-recording device. Brain waves were classified into 3 groups: slow (0.0–8.0 Hz), alpha (8.0–13.0 Hz), and fast waves (13.0–30.0 Hz). Subjects kept the MRT instrument on their head for 3 minutes with their eyes open while brain wave rates were being recorded. Digital data on each brain wave group in increments of 0.25 Hz up to 30 Hz was automatically recorded every 0.5 second for 3 minutes. Brain wave data identified as extraneous noise or stimuli was excluded from analysis.

Brain waves and the GHQ scores were measured and collected on days 1, 8, and 15. [Figure 2]

5. Reliability and validity of the measuring instruments

The reliability of the MRT results has been pretested and certified in this study (Cronbach’s $\alpha = 0.817$, $p<0.05$), and the reliability and validity of the GHQ scale has also been established.\textsuperscript{17}

6. Ethical considerations

Oral and written informed consent was obtained from each hospital and subject. Subjects were informed that they were free to exit the study at any time. The study was approved by the Gunma University School of Medicine Ethical Review Board (authorization No.11–16) in September 2011, and was conducted in accordance with the Declaration of Helsinki.

7. Data analysis

Fundamental statistics were used to analyze brain wave and GHQ data. Data for slow waves, alpha waves, fast waves, and GHQ scores were calculated and analyzed for variations (paired-sample $t$-test) and cor-

Fig. 1 A portable, single-channel EEG recording device (MRT) Neuro Sky (www.neurosly.jp)
Subjects who consented: $n = 25$  
Major depression ($n = 19$)  
Schizophrenia ($n = 1$)  
Bipolar Disorder ($n = 3$)  
Personality Disorder ($n = 2$)

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**IV. Results**

1. **Initial analyses**

Twenty-five hospital patients consented to participate after a verbal explanation of the study. Patient diagnoses included depression ($n = 19$), schizophrenia ($n = 1$), bipolar disorders ($n = 3$), and personality disorders ($n = 2$) according to the International Classification of Diseases, 10th Revision.

Twelve subjects (10 males and 2 females; age 22–55 years; mean ± SD, 39.2 ± 7.9 years) who attended the tests more than twice with a comparatively stable mental condition were selected as the final subjects [Table 1]. The data measured on each of the 3 days (day 1, 8, and 15) are presented in Figure 2.

2. **Variation and correlations among the data obtained during the control period**

Percent change for each brain wave did not significantly change during the control period. Neither did mean GHQ scores also not significantly change (varia-
Gum chewing to alleviate depression

Table 1  Descriptive statistics

<table>
<thead>
<tr>
<th>variates</th>
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<tr>
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<td></td>
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<td>12.1</td>
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<td>fast waves (%)</td>
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</tr>
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<td>11.9</td>
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SD: standard deviation  GHQ: general health questionnaire

Table 2  Results of paired-sample t-tests

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<th>variates</th>
<th>Differences between paired samples</th>
<th>mean value</th>
<th>S.D.</th>
<th>S.E.</th>
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<th>t-ratio</th>
<th>Degree of freedom</th>
<th>p-value (two-sided)</th>
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<td>5.51</td>
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<td>16.00</td>
<td>0.60</td>
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<tr>
<td>alpha waves</td>
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<td>-3.29</td>
<td>7.20</td>
<td>2.40</td>
<td>-8.82</td>
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<td>-1.37</td>
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<td>2nd test vs 3rd test</td>
<td>-2.61</td>
<td>4.91</td>
<td>1.48</td>
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<td>0.31</td>
<td>-2.44</td>
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<tr>
<td>fast waves</td>
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<td>8.78</td>
<td>2.93</td>
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<td>-1.68</td>
<td>8</td>
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<td></td>
<td>2nd test vs 3rd test</td>
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<td>5.83</td>
<td>1.76</td>
<td>-6.82</td>
<td>1.02</td>
<td>-1.65</td>
<td>10</td>
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<td>GHQ-30 scores</td>
<td>1st test vs 2nd test</td>
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<td>5.10</td>
<td>1.54</td>
<td>-0.07</td>
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<td>10</td>
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<td>2nd test vs 3rd test</td>
<td>1.75</td>
<td>4.49</td>
<td>1.30</td>
<td>-1.11</td>
<td>4.61</td>
<td>1.35</td>
<td>11</td>
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</tbody>
</table>

paired t-test  * p < .05  ** p < .01
SD: standard deviation  SE: standard error  GHQ: general health questionnaire

Table 3  Correlation co-efficient of paired samples

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<th>p-value</th>
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<td>.188</td>
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<tr>
<td>2nd test vs 3rd test</td>
<td>12</td>
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<td>.005*</td>
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</table>

* p < .05  ** p < .01
c.c: correlation coefficient

tion 3.36; SD, 5.10; p = 0.054; paired t-test; [Table 2] [Figure 6].

3. Variation and correlations among the data obtained during the intervention period

The percentage of alpha waves increased significantly during the intervention period (variation, 3.61%; SD, 4.91, p = 0.035; paired t-test [Table 2]
Figure 4. Alpha waves * * p < .01

Figure 5. Fast waves

Figure 6. GHQ-30 scores

4. Reproducibility of measured brain wave values

The reproducibility of measured brain wave values was examined using the data of the 12 subjects. Individual data for slow, alpha, and fast waves obtained between day 1 and day 3 were collated to examine reproducibility. The mean value of inter-class correlation (ICC, 0.710; p = 0.014) confirmed a significantly high reproducibility among the individual brain wave values measured on each test.

5. Visualization of temporal response by a brain wave algorithm

A three-dimensional model of frequency (Hz), quantity (device-based), and time (60 seconds) was
created to visualize the temporal response and digital MRT data as a brain wave algorithm [Figure 7]. Individual data were used with subjects’ consent as an anonymous general model case. The figure visually shows the variation of brain waves in each range of frequency groups over 60 seconds.

V. Discussion

1. Brain waves

Percentage of alpha waves increased significantly during the intervention period. Previous studies have reported a significant relationship between the amount of alpha waves and the activation of serotonergic neurons within the brain. The result of the present study (that alpha waves significantly increased during the period when the subjects were kept on chewing gum) could suggest the possibility that habitual gum chewing causes serotonergic neuron activation in the subjects.

Table 1 and Figure 7 show that slow waves usually comprise around 80% or more of a whole brain wave; moreover, they have a sensitive reactivity. A decrease in the percentage of slow waves indicates stabilization of the mental condition, whereas an increase in the percentage of alpha waves indicates relaxation of the mental condition. Moreover, an increase in the percentage of fast waves indicates activation of the mental condition. Individual brain wave effects were analyzed by paired t-tests in order to demonstrate significant results for the 15-day research program.

With regard to correlations between the data
measured on day 8 and day 15, variations in alpha waves showed strongly significant correlations. This indicates that the amount of alpha waves uniformly increased on individual patterns.

2. Evaluation of mental health
Mean subject scores were comparatively higher than that of the general public, which were over the cut-off point 7/8 of GHQ-30. Mean GHQ scores gradually decreased during the entire experimental period; however, there was no significant variation between the control period and intervention period.

3. Variations and correlations among brain wave and mental health data
In the research of the present study, all subjects attended a meeting with the researcher for about 10 minutes prior to every test, where the researcher explained the purpose and method of the investigation and collected preliminary data. Therefore, a good rapport had already formed between each subject and the researcher during the control period, which naturally created more relaxed environment that could have affected the subjects’ brain waves and GHQ scores.

Some improvements were recorded in a few subjects even before the intervention period, most likely due to the prior briefing by the researcher and the subject’s acceptance of the subsequent effects of the investigation. Although 3 subjects had GHQ scores below the cut-off point at day 1, 6 subjects managed to achieve scores below the cut-off point at day 3. This means that half the subjects were mentally healthy at the end of the intervention. The percentage of alpha waves, which was determined as a key factor for evaluating the effects of gum chewing, increased significantly after gum chewing for 7 days.

VI. Limitations of the Study
Although this research has reached its aims, there were some unavoidable limitations. First, because of the time limit, this research was conducted only on patients who could attend the intervention, resulting in a small sample size. Therefore, in order to generalize the results, the study should have involved more patients as subjects. Second, because of the limitation of group size, the intervention period followed the control period for each subject. Ideally, the subjects should have been divided into 2 groups for intervention and control. Friendly communications between one researcher and patients on day 1 and expectations of the subjects during the control period could have affected the results of the GHQ score on days 2 and 3.

VII. Conclusions
According to the results in the present study, an intervention of gum chewing for patients with depression may be beneficial in maintaining their mental health. A further assessment would be necessary to confirm the impact of gum chewing on mental health in patients with depression.

VIII. Acknowledgments
We appreciate the cooperation of the staff and patients of the psychiatric day hospitals included in this study. The authors would like to thank Prof. Chifumi Sato at Tokyo Medical and Dental University for the valuable discussion throughout this study, and NeuroSky (www.neurosky.jp) for supplying the single-channel EEG recording device.

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