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Original article

Masticatory performance alters stress relief effect of gum chewing

Keisuke Nishigawa DDS, PhD[*], *Yoshitaka Suzuki DDS, PhD*, *Yoshizo Matsuka DDS, PhD*

Department of Stomatognathic Function and Occlusal Reconstruction, Institute of Biomedical Sciences, Tokushima University Graduate School, Tokushima, Japan

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ABSTRACT

Purpose: We evaluated the effects of gum chewing on the response to psychological stress induced by a calculation task and investigated the relationship between this response and masticatory performance.

Methods: Nineteen healthy adult volunteers without dental problems undertook the Uchida–Kraepelin (UK) test (30 min of reiterating additions of one-digit numbers). Before and immediately after the test, saliva samples were collected from the sublingual area of the participants. Three min after the UK test, the participants were made to chew flavorless gum for 3 min, and the final saliva samples were collected 10 min after the UK test. The experiment was performed without gum chewing on a different day. Masticatory performance was evaluated using color-changing chewing gum.

Results: Salivary CgA levels at immediately and 10 min after the UK test were compared with and without gum chewing condition. Two-way repeated measures analysis of variance revealed significant interaction between gum chewing condition and changes in CgA levels during post 10 min UK test period. A significant correlation was found between changes in CgA levels and masticatory performance in all participants.

Conclusion: Our results indicate that gum chewing may relieve stress responses; however, high masticatory performance is required to achieve this effect.

1. Introduction

Mastication is one of the most important oral functions. Recently, however, several studies have revealed a significant role of mastication in maintaining mental health. Reportedly [1–5], habitual gum chewing relieves anxiety and mental stress. Several studies [6–13] evaluating salivary markers of stress showed that gum chewing decreases the level of salivary cortisol after experimental stress loading. Cognitive function, memory, and attention may also be improved by gum chewing [14–16].

When humans experience stress, the hypothalamic–pituitary–adrenal axis (HPA) and sympathoadrenal system (SAS) are activated, inducing a stress response. The HPA facilitates the release of cortisol, whereas the SAS induces the secretion

* *Corresponding author at*: Department of Stomatognathic Function and Occlusal Reconstruction, Institute of Biomedical Sciences, Tokushima University Graduate School, 3 Kuramoto-cho, Tokushima 770-8504, Japan. Tel.: +81 886 33 7350; fax: +81 886 33 7391.
E-mail address: keisuke@tokushima-u.ac.jp (K. Nishigawa).

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of catecholamine, both of which enhance the human body's ability to deal with stress. Because SAS activation precedes HPA activation, catecholamine responds more quickly to stress compared with cortisol, and its measurement is therefore suitable for rapid detection of low stress. Conversely, cortisol can be detected in saliva, blood, and urine. It can be sampled easily and is frequently adopted as the standard index for evaluating stress levels. Although catecholamine exhibits a better response to stress compared with cortisol, it is difficult to detect this stress hormone in saliva samples.

Chromogranin A (CgA) is an acidic glycoprotein released with catecholamine by the adrenal medulla and sympathetic nerve endings. Because CgA can be detected in saliva samples, it represents a suitable stress index substitute for catecholamine [17–19]. The validity of salivary CgA levels as an indicator of stress has been confirmed by experimental stress tests, including cognitive tests, noise exposure, and venipuncture [20–22].

Many previous studies [6–13] on the stress-relieving effects of gum chewing measured salivary cortisol as the stress index. Because the response to stress mediated by the HPA is affected by the menstrual cycle [23], some of these reports included only male participants [7–9,12]. However, CgA is an SAS index that can be expected to respond quickly to psychological stress in both male and female participants.

Soeda et al. [12] evaluated the effects of gum chewing on experimental stress loading by recording surface electromyographic (EMG) activity of the masseter during gum chewing and concluded that forceful chewing relieves stress more effectively compared with weak chewing. The detailed mechanism underlying the stress-relieving effects of gum chewing remains to be identified. However, this report showed that, qualitatively, gum chewing produces a stress-relieving effect.

Several approaches have been utilized to evaluate chewing quality. Objective methods such as measurement of maximum occlusal force and/or occlusal contact at the maximum intercuspal position have been used to evaluate chewing function. These parameters are known to contribute to masticatory performance, although they may not completely reflect chewing function [24–26]. Direct analysis of chewed food samples is effective for investigating chewing function. Recently, various materials such as gummy jelly, wax cubes, and gum have been used to assess chewing quality [27–30]. Numerical analysis of experiments using these materials indicates masticatory performance [24]. In this study, we verified the ability of gum chewing to relieve acute experimental stress by evaluating salivary CgA levels in response to the Uchida–Kraepelin (UK) test with and without gum chewing and investigated the relationship of masticatory performance and masticatory muscle activity to the stress-relieving effects of gum chewing.

2. Materials and methods

2.1. Participants

Nineteen adult volunteers (nine males, 10 females; mean age, 25.9 years) participated in this study. All participants were healthy; none had any dental problems or were taking any medication. Participants with missing teeth (except for the third molar), pathological malocclusion, full-veneer restoration of molars, or a smoking habit were excluded.

Before they provided consent to participate, the participants were informed about the procedures and experimental stress test. This research was approved by the Research Ethics Committee of Tokushima University Hospital, Tokushima, Japan (No. 1424).

2.2. Measurements

The salivary stress marker CgA was measured to evaluate acute physiologic responses to experimental stress. Resting saliva from the sublingual area was obtained with an oral swab and cryopreserved. Saliva samples were analyzed by enzyme-linked immunosorbent assay for the quantitative measurement of CgA levels.

Surface EMG activity of the masseter muscle during gum chewing was recorded to evaluate the magnitude of chewing force. Miniature biomedical waveform recorders (Actiwave®; CamNtech Ltd., Cambridge, UK) were used to record the EMG activity of the masticatory muscles.

Masticatory performance was assessed using color-changing chewing gum (Masticatory Performance Evaluating Gum XYLITOL®; Lotte Co., Ltd., Saitama, Japan), which changes color with chewing. Color change was measured using a colorimeter (CR-13; Konica Minolta, Inc., Tokyo, Japan) after 80 chewing cycles.

2.3. Procedure

All participants undertook the Uchida–Kraepelin (UK) test [31–41], which is a psychodiagnostic examination involving reiterative additions of one-digit numbers for 30 min after speech guidance. Experiments were initiated between 13:00 and 14:00 h. From the night before the experiment, participants were asked to refrain from consuming alcohol, caffeinated drinks, and spicy foods. Experiments were performed in a quiet laboratory isolated from the external environment.

A disposable electrode was attached to the skin over the masseter muscle on the habitual masticatory side and connected to the EMG lead. Participants were then instructed to sit on a chair and try to relax for 30 min. After this relaxation period, initial (pre-UK) saliva samples were collected; subsequently, participants undertook the UK test. Immediately after the UK test, further (post-UK) saliva samples were collected. Three minutes after the UK test, the participants were instructed to chew flavorless gum (Check Buff Salivary Gum; HORIBA, Ltd., Kyoto, Japan) for 3 min using regular chewing force. Rhythmic audio signals were used to regulate the chewing rate at 1.5 Hz. After gum chewing, participants were asked to relax for 4 min, following which the final saliva samples were collected (10 min after the UK test). At the end of the experiment, the participants were asked to perform maximum voluntary clenching for 3 s three times at 1-min intervals to obtain a calibration signal for EMG analysis. To ensure the exact timing of each experimental step, all procedures were performed according to prerecorded audio guidance (Fig. 1).

Taking over a month interval precede or follow the experiment, the same procedures were performed without