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Original Article

Effects of oral stimulation with capsaicin on salivary secretion and neural activities in the autonomic system and the brain

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Abstract *Background/purpose:* Although it has been reported that capsaicin ingestion has effects of protecting stomach mucosa and promoting energy consumption, physiological responses to oral stimulation with capsaicin has not been elucidated. Therefore, we investigated the effect of oral capsaicin stimulation on oral health and mental conditions by measuring changes in salivation, autonomic nervous activity and electroencephalogram (EEG).
Materials and methods: Eighteen healthy adults participated in this study. The stimulus concentrations of capsaicin and five basic taste solutions were determined based on the measured threshold of each stimulus in each subject. The weight of secreted saliva and the changes in concentrations of salivary secretory immunoglobulin A (SIgA) induced by capsaicin and taste stimuli were measured. Salivary α-amylase activity and heart rate variability (HRV) were measured as indicators of autonomic nervous activity. From EEG, psychological condition was analyzed by measuring the powers of theta, alpha, and beta bands.
Results: The salivary secretion rate was significantly increased by stimulation with capsaicin, NaCl, and citric acid compared with deionized water, and capsaicin demonstrated the most potent effect among tested stimuli. The secreted amount of SIgA per minute was elevated by capsaicin stimulation. Salivary α-amylase activity and HRV analysis demonstrated an elevation of sympathetic nervous activity induced by capsaicin. EEG analysis showed a significant increase in beta band power.

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Conclusion: These results suggest that oral stimulation with capsaicin may be effective in improving oral conditions by increasing salivary flow and SIgA secretion, and in enhancing physical and mental conditions as indicated by sympathetic nerve and EEG changes.

Introduction

Pungent seasoning such as chili pepper makes foods more palatable and stimulates appetite. Capsaicin, the major pungent ingredient in chili pepper, is composed of vanillylamine and fatty acid. The vanillyl residue of capsaicin binds to the transient receptor potential cation channel subfamily V member 1 (TRPV1) and generates depolarization of the free nerve endings expressing TRPV1, which results in impulses conveying the information of irritant or pain sensation. Capsaicin applied to the mouth activates nociceptive trigeminal neurons and is recognized as pungent taste in the cerebral cortex.[1] In addition to causing pungent taste, ingestion of capsaicin induces various biological responses. Ingested capsaicin was reported to have effects of protection against injury of the stomach mucosa,[2–4] increase in serum adrenalin, and promotion of energy metabolism.[5,6]

Regarding the effect of oral stimulation with capsaicin, Ebihara et al.[7] reported that capsaicin is effective for enhancement of the swallowing reflex in dysphagia patients, however few studies have been performed on the influences of capsaicin on oral function and nervous system.[8] Since saliva has important functions such as buffering, protection, lubrication, tissue repair and antibacterial actions, the approach of increasing salivary flow is quite important for promotion of oral and systemic health.[9,10] Though taste stimulation is well-recognized to increase salivary secretion, known as gustatory-salivary reflex,[11,12] the effect of pungent stimuli on salivation has never been investigated. Therefore, we investigated the effect of oral stimulation with capsaicin on salivary secretion and compared the effectiveness of capsaicin with those of the five basic tastes. In this study, we determined the stimulating concentration of each stimulus based on individual threshold rather than the constant concentration, because the effectiveness of stimulus on salivary secretion was considered to vary depending on individual sensitivity to each stimulus. In addition to salivary secretion, we measured the change in the concentration of salivary secretory immunoglobulin A (SIgA), the primary factor of mucosal immunity, induced by capsaicin.[13,14]

Furthermore, it was presumed that capsaicin-induced responses were accompanied by changes in autonomic nervous activities, since modulation of sympathetic nervous activity was observed with ingestion of capsaicin.[15] In order to investigate this issue, salivary α-amylase activity and variation of heart rate were measured as indices of autonomic nervous activities. Salivary α-amylase is a digestive enzyme and increased with sympathetic nervous activation.[16] Power spectral analysis of fluctuation of heart rate from electrocardiogram (ECG) has been generally used for evaluation of autonomic nervous activities because the heart rate fluctuates reflecting autonomic nervous activities.[17–20]

Since pungent seasoning causes strong sensation, psychological statuses can be changed by oral stimulation with capsaicin. In order to detect the psychological changes induced by capsaicin, we measured electroencephalogram (EEG), because power spectral analysis of EEG has been conventionally utilized to understand psychological status.[21–23] Thus, we comprehensively analyzed the effects of oral stimulation with capsaicin on oral function, autonomic activity and mental condition from various indices in this study.

Materials and methods

Subjects

Eighteen healthy adults (six males and 12 females) aged 26.6 ± 4.5 (the mean $\pm$ SD) years voluntarily participated in this study. All subjects were non-smokers and not on any medications, and had no oral problems. They refrained from eating and drinking anything except water for 2 h before the experiment.

Pungent and taste stimuli

The solutions used in the experiment are listed in Table 1. Capsaicin was dissolved in 1 mL of ethanol (99.5%) and then diluted to eight step concentrations with deionized water (DW). For the five basic tastes, sucrose, quinine hydrochloride (QHCl), monosodium glutamate (MSG), NaCl and citric acid (CA) were used for sweet, bitter, umami, salty and sour stimuli, respectively. These substances were diluted with DW to prepare eight step concentrations in two-fold serial dilution.

Experimental procedures

The subjects were seated on an armchair and the electrodes for recording ECG and EEG were attached on the respective parts of the body. One stimulating session in the experimental procedure involved collection of unstimulated saliva for 1 min, oral stimulation and collection of saliva for 1 min, collection of saliva for 1 min after stimulation, and an intermission of at least 4 min. This protocol of one session was repeated for stimulations of the five

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