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Original article

Properties of tonic episodes of masseter muscle activity during waking hours and sleep in subjects with and without history of orofacial pain

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ABSTRACT

Purpose: To provide a scientific data related to the tonic activity of masseter muscle in subjects with and without history of orofacial pain during their normal daily life.
Methods: Thirty-three subjects were divided into two groups, a pain history group (PHG) and a non-pain history group (non-PHG), based on their responses to the Research Diagnostic Criteria for Temporomandibular Disorders questionnaire. After excluding four subjects with incomplete recordings, full-day masseter muscle surface EMGs of 29 subjects (10 men, 19 women; mean age 24.1 years) were analyzed. Tonic episode (TE) was defined as continuous EMG activity with a duration at least 2 s with intensities above twice the baseline noise level. TEs were classified into 6 strength categories (<7.5%, 7.5–10%, 10–15%, 15–25%, 25–40% and >40% of the maximum voluntary clenching (MVC)). The mean duration of activity observed in the non-PHG + 2 SD was adopted as a cutoff for identifying sustained TE.
Results: During waking hours, the incidence of sustained TEs was significantly higher in the PHG than in the non-PHG ($p < 0.05$). The incidence and total duration of sustained TEs were significantly higher in the PHG than in the non-PHG at intensities of 7.5–10% MVC, 10–15% MVC, and 15–25% MVC ($p < 0.05$). No significant difference was observed during sleep.
Conclusions: Within the limitations of this study, it would be concluded that sustained TEs may have a correlation with orofacial pain and the intensity range of 7.5–25% MVC would be an important range for future clenching studies

1. Introduction

Excess masticatory muscle activity (MMA) is believed to cause undesirable changes in the stomatognathic system, such as tooth wear and a reduced prognosis of dental restorations [1]. Excess activity of masticatory muscles is sometimes broadly referred to by the term “bruxism”. Quantitative evaluation of sleep bruxism has been undertaken for a long time using polysomnography (PSG), which has resulted in many valuable findings on MMA. Another common modality that has been used for the evaluation of sleep bruxism is subjective reporting using questionnaires.

Meanwhile, excessive MMA during wakefulness was recently reported to have a more destructive effect on the dentition than MMA during sleep [2]. For the evaluation of waking MMA during daily life, ambulatory electromyography (EMG) recorders have been developed and improved [3–7]. Kothari et al. [7] stated that the use of ambulatory EMG devices might open a path for studies to determine levels of jaw muscle activity in the clinical setting. In particular, the latest ambulatory equipment’s has made it possible to record and analyze whole-day EMG in daily life condition [8,9].

Excess MMA may not necessarily indicate excessive strength of muscle activity, but it may indicate an increased duration of sustained muscle activity. Low-level clenching has been one of the issues of interest in relation to the etiology of temporomandibular disorders (TMD) [10]. Also, in achieving sustained muscle activity, both duration and strength are important influential factors for estimating the effect of the task [11]. Based on these studies, it would be beneficial to reveal the various properties of MMA not only during sleep but also during waking hours in daily life condition. At present, because of the limited availability of whole-day recording systems, only limited findings on whole-day MMA have been acquired so far.

This study aimed to reveal the properties of whole-day MMA in subject groups with and without a history of orofacial pain

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focusing on tonic activity. Our null hypothesis was that there is no significant difference in duration and strength of masseter muscle activity between the participants with and without a history of orofacial pain.

2. Materials and methods

2.1. Subjects

A cross-sectional observational study was performed at the Okayama University Dental School from September 1st to September 30th, 2015. Thirty-three students (11 men and 22 women; mean age, 23.9 ± 4.2 years) participated in this study. All subjects completed the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) questionnaire. The subjects were divided into two groups based on the results of the RDC/TMD questionnaire. Subjects who answered yes to pain question #1, "Have you ever had pain in your jaw, temple, in the ear, or in front of the ear on either side?", or headache question #5, "In the last 30 days, have you had any headaches that included the temple areas of your head?", were classified into the pain history group (PHG). Subjects who answered no to these questions were classified into the non-pain history group (non-PHG). Exclusion criteria included the following: a history of head trauma, rheumatoid arthritis, intracranial disorders, vascular disorders, or the use of medications such as muscle relaxants, anticonvulsants, antidepressants, or anxiolytics. All subjects were instructed not to chew gum during the EMG measurements.

All subjects received an explanation of the nature and purpose of the study, and they all provided their written informed consent to participate in the study. The study protocol was approved by the ethics committee of Okayama University (Ken 1508-003).

2.2. EMG recording procedures

EMG recordings of the left masseter muscle were performed using a portable EMG device in accordance with the methods by Kawakami et al. [2]. All subjects wore EMG device in two consecutive days, the first day is for acclimatization and the next day is for data collection. Recordings were made on a weekday, beginning at 9 a.m. and continuing until the subject awoke the next morning. The EMG recording procedures were performed by the same examiner (SK). The ambulatory EMG recording hardware consisted of an analog signal processing and differential amplification integrated hybrid circuit (NB-6201HS; Nabtesco Co., Kobe, Japan), which included an analogue high-pass filter (10 Hz) and an analogue low-pass filter (1000 Hz), as well as a two-channel digital recorder (ICR-PS004 M; Sanyo Electric Co., Ltd., Osaka, Japan). Recording was made on the digital recorder as a linear recording with sampling frequency 22.05 kHz. Before the electrodes were affixed to the body, the skin was vigorously rubbed with a pad soaked in 70% ethyl alcohol. The EMG of the left masseter muscle was recorded using three disposable Ag/AgCl differential surface electrodes (Vitrode F-150S; Nihon Kohden Corp., Tokyo, Japan), whose size was modified to be 6 × 15 mm before use, with center-to-center distances of 15 mm. To standardize masticatory muscle EMG, each subject was instructed to perform maximum voluntary clenching for three times for 2 s at intervals of 2 s in the beginning of recording. To distinguish EMG activity during speech, a voice-operated trigger switch (VOX) was used with a condenser microphone attached to the neck skin adjacent to the larynx [8]. The electrodes, condenser microphone, and cables were secured to the skin with thin biocompatible adhesive tape (Cathereep FS 1010; Nichiban Co., Ltd., Tokyo, Japan).

2.3. EMG data analysis

Recorded EMG data were processed off-line, filtered with a low-pass filter (200 Hz) and a notch filter (60 Hz) using sound-editing software (Sound Engine, Coderium Co., Ltd., Sapporo, Japan), and down-sampled to 100 Hz. According to the method reported by Kumazaki et al. [8]. EMG signals accompanied by positive VOX signals were regarded as speech activities and excluded from subsequent analysis. The EMG recordings associated with mastication during meals and calibration were also excluded from subsequent analysis.

To discriminate EMG data recording from the baseline noise, the threshold to detect minimum masseter muscle activity was set at twice the baseline noise level observed under resting conditions of the mandible at the beginning of the EMG recording [12]. This threshold was utilized for the analysis of low-level masseter muscle activity in this study. A tonic episode (TE) of the masseter muscle was defined as continuous EMG activity higher than the threshold with a duration at least 2.0 s. The duration of 2.0 s to identify TE was adopted from the report by Lavigne et al. [13] which classified bruxism event during sleep, because no classification of diurnal parafunctional masticatory muscle activity has been established so far. The mean %MVC was calculated for each TE. TEs were classified according to the calculated mean intensity of the EMG signal and the duration. As reported by Farella et al. [11] EMG activity was analyzed using the intensity categories of <7.5% MVC, 7.5–10% MVC, 10–15% MVC, 15–25% MVC, 25–40% MVC, and >40% MVC. Sustained TEs were screened using the cutoff value of the mean + 2 SD duration observed in the non-PHG. The frequency and total duration of clenching were calculated with software that was programmed by AHM. To investigate the possible effect of sleep bruxism on orofacial pain, sleep bruxism episodes were also evaluated using Lavigne's criteria [13] in both groups.

2.4. Statistical analysis

We compared the difference between two groups (PHG and non-PHG) in the number of sustained TE episodes during awake and sleep, mean incidence and mean total duration of short and sustained TE using Mann–Whitney *U* test, as Kolmogorov–Smirnov test showed that the data were not normally distributed. Mann–Whitney *U* test was also used to examine the difference of the number of muscle activities (phasic, tonic, and mixed) between two groups.

The statistical analysis software used was SPSS version 22.0.0 (IBM, Tokyo, Japan). A significance level of 0.05 was adopted for all statistical tests.

3. Results

Among the 33 subjects, one subject in the non-PHG who had unexpected alcohol consumption was excluded from the study. The Kolmogorov–Smirnov test showed a normal distribution of baseline noise intensity in the PHG and non-PHG. Grubbs' test for outliers was then applied to detect outlying high baseline noise intensity. Because EMG data of one subject in the PHG and two subjects in the non-PHG had outlying high baseline noise, these three sets of data also were excluded from subsequent analysis. The mean baseline noise intensity of the PHG and non-PHG were 2.84 ± 1.22% MVC and 3.05 ± 1.15% MVC, respectively. The outlying baseline noise values were 7.70% MVC (PHG), 6.94% MVC (non-PHG), and 9.80% MVC (non-PHG), which were all higher than 5% MVC. After excluding these three subjects, the mean baseline noise for the remaining subjects was 2.94 ± 1.18% MVC. The EMG recordings associated with mastication activity was removed in both groups (The average of total duration in PHG and non-PHG

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