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ORIGINAL ARTICLE

Electromyographic activity during awake tooth grinding tasks at different jaw posture in the sagittal plane

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Abstract

Objective. The goal of this study was to evaluate the electromyographic (EMG) activity of the anterior temporalis, suprahyoid, infrahyoid and trapezius muscles during tooth grinding at different jaw posture tasks. ***Materials and methods.*** Participants were 30 healthy subjects with natural dentition, bilateral molar support and incisive protrusive guidance. Bipolar surface electrodes were located on the right side of the subject. EMG recordings were performed in the following tasks: (A) Eccentric grinding from intercuspal position to protrusive edge-to-edge contact position; (B) concentric grinding from protrusive edge-to-edge contact position to intercuspal position; (C) eccentric grinding from intercuspal position to the maximum voluntary retrusive position; and (D) concentric grinding from the maximum voluntary retrusive position to intercuspal position. The results were analyzed statistically by Friedman test and Wilcoxon signed rank-sum test. ***Results.*** EMG activity in the anterior temporalis and infrahyoid muscles was significantly higher during task C than the other tasks. EMG activity in the suprahyoid muscles was significantly higher during task C than task D. EMG activity in the trapezius muscle was significantly higher during task C than tasks A and B. ***Conclusions.*** The higher EMG activity recorded in task C could become important when its frequency, duration and magnitude are enough to exceed the adaptation capability of the individual.

Key Words: *craniocervical mandibular unit, tooth grinding, electromyography*

Introduction

Bruxism is defined as the actions of clenching and/or grinding the teeth while awake or while asleep [1]. Tooth grinding is an activity of major concern for dentists due to its many clinical implications: destruction of tooth structure [2], damage and/or fracture of dental rehabilitation, exacerbation of temporomandibular joint disorders and/or induction of temporalis muscle tension, headache and grinding sounds that may also interfere with the sleep of family or life partners [3].

In contrast to sleep-related oral parafunctional behaviours, little is known about awake oral parafunctional behaviours [4]. To the author's knowledge, electromyographic (EMG) pattern of muscles integrating the cranio-cervical-mandibular unit (CCMU) during tooth grinding in the sagittal plane has not been previously reported in the same subject with incisive protrusive guidance. Moreover, Torisu et al. [5] suggest that future studies using eccentric and concentric grinding have to be done for a better understanding of the physiology of CCMU.

The influence of the number and location of tooth contacts on EMG activity of elevator muscles during maximal voluntary clenching has been reported [6,7]. Masseter and sternocleidomastoid EMG activity during protrusive tooth grinding has also been reported [8]. However, little is known about the EMG pattern of anterior temporalis, suprahyoid, infrahyoid and trapezius muscles when the subject is tooth grinding in protrusive or retrusive positions either to or from intercuspal position (IP). Therefore, this was the aim of this study, done in a healthy subject, without altering his/her oral environment. This knowledge will be the key to compare in a

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future study this EMG activity in patients with myofascial pain.

Materials and methods

Subjects

The current study included 30 healthy subjects (15 females and 15 males) within an age range of 18–30 years and with a mean age of 22 years. All subjects had complete natural dentition (excluding the third molars), bilateral Angle Class I, normal overbite and overjet, protrusive incisive guidance, no prior orthodontic treatment, no history of orofacial pain or craniomandibular-cervical-spinal disorders or oral self-report of bruxism (clenching or grinding), no history of trauma or fractured teeth and no large restorations that included an incisal edge or one or more cusps. Nobody was on therapeutic medication that could influence muscle activity. Participants were students enrolled at the Dental and Medicine School of the University of Chile. The Institutional Review Board approved the study protocol and informed consent was obtained from all enrolled participants.

During the clinical static occlusal exam, Angle Class I was defined as the mesiobuccal cusp of the maxillary first permanent molar occluding in the mesiobuccal groove of the mandibular first permanent molar. During the clinical dynamic occlusal exam, subjects were asked to bite in the intercuspal position (IP) and then slide the mandible in a protrusive excursion with upper and lower incisors in contact position, without posterior occlusal contacts.

An expert and ad-hoc clinical training dentist performed all the static and dynamic occlusal examinations. The period during which the examiner selected the subjects was 10 weeks.

Electromyography

Bipolar surface electrodes (BioFLEX: BioResearch Associates, Inc., Brown Deer, WI) were located on the right anterior temporalis, suprahyoid, infrahyoid and trapezius muscles (Figure 1).

The skin area was cleaned with alcohol. The electrodes were placed on the anterior temporalis muscle 1 cm above the zygomatic arch and 1.5 cm behind the orbital border and the upper electrode was placed

Figure 1. The electrodes are shown in position.

1.5 cm over the lower electrode and parallel to the main direction of muscle fibres [9]. The electrodes were placed on the suprahyoid muscles following the direction of the muscle fibres, according to the technique described in previous studies [10]. For infrahyoid EMG activity recordings, the electrodes were placed on the anterior prominent part of the thyroid cartilage, 1 cm laterally to the anterior median line [11]. In the trapezius muscle the upper electrode was fixed at the fourth cervical spine level (C4), 2 cm laterally to the spinous process of that vertebra; the lower electrode was fixed 1.5 cm below the vertical line [12]. A surface ground electrode was attached to the forehead.

The EMG signals were amplified (Model 7P5B preamplifier, Grass Instrument Co. Quincy, MA), rectified and integrated (time constant of 1 s) and then recorded online in a computer exclusively for the acquisition and processing of EMG signals. The system was calibrated before each record.

EMG activity was recorded while the subject was in the standing position, maintaining his/her stance with feet at 10 cm apart, with his/her eyes open, looking straight ahead and his/her head in the postural position. Each subject underwent three EMG recordings of anterior temporalis, suprahyoid- and infrahyoid and trapezius muscles during the following tasks: (A) Eccentric grinding from IP to protrusive edge-to-edge contact position; (B) Concentric grinding from protrusive edge-to-edge contact position to IP; (C) Eccentric grinding from IP to the maximum voluntary retrusive position; and (D) Concentric grinding from the maximum voluntary retrusive position to IP.

The amplitude of EMG data to each given task was normalized using the mean value obtained during maximal voluntary clenching in IP, because it is the more stable and common occlusal contact position. During clenching in IP the subjects were instructed to clench as hard as they could. The following IP ratio [13] was used to normalize muscle activity:

$$\text{IP ratio} = \text{EMG recorded during each grinding task} / \text{EMG recorded during maximum clenchig in IP}$$

In order to reproduce the same edge-to-edge protrusive contact position, a vertical mark was made on the upper and lower right central incisors. To reproduce the same retrusive contact position, a vertical mark was also made on the upper and lower right first premolar.

The recording tasks were demonstrated and explained to each subject using stone dental casts. Then, all individuals repeated the conditions at least 5-times prior to the recordings, while having the subjects look into a mirror. During eccentric and concentric grinding tasks, they were asked to grind as hard as they could while they performed the movement. The initial and final jaw positions were visually checked during the EMG recordings. Before performing EMG recordings, the sequence of tasks was randomized to assure similar basal EMG activity.

No trial lasted longer than 10 s. It is reported [14] that muscle fatigue occurs in the masseter after 30 s of isometric contraction (clenching), whereas 30 s of combined concentric and eccentric contractions (grinding) induce no fatigue. To avoid muscular fatigue, a rest period of 1 min between each task was allowed. In addition, a 3-min resting period after each task change was included [15].

To obtain the average value of each curve, it was measured every 0.1 s from the beginning to the end of the recording by means of software specially designed for this purpose. The mean value of the three curves obtained for each subject at each task was used. Task-to-task variability in the anterior temporalis muscle was ≤20%; in the suprahyoid muscles it was ≤18%; in the infrahyoid muscles it was ≤24%; and in the trapezius muscle it was ≤22%.

Statistical methods

EMG activity recorded presented a non-normal distribution of data ($p < 0.05$; Shapiro Wilk test); therefore, overall comparison among tasks in each muscle was made by Friedman test and the p-value was obtained assuming chi-square distribution with 3° of freedom ($p < 0.05$). The paired comparison of the tasks in each muscle was made by the non-parametric Wilcoxon signed rank-sum test. We computed median and IQ range. The p-value for post-hoc comparison was 0.0083 due to the fact that we have done six comparisons (0.05/6). The data were analyzed using SYSTAT 13®.

Results

Overall tasks comparison in the anterior temporalis EMG activity showed a p-value of 0.000 (Friedman test). EMG activity during task C was significantly higher than tasks A, B and D. Activity during tasks B and D were significantly higher than task A (Figure 2 and Table I).

Overall tasks comparison in the suprahyoid EMG activity showed a p-value of 0.000 (Friedman test). EMG activity during task C was significantly higher than task D. The other comparisons did not show significant differences (Figure 3 and Table I) (non-parametric Wilcoxon signed rank-sum test).

Infrahyoid EMG activity during task C was significantly higher than tasks A, B and D. Activity during task D was significantly higher than tasks A and B (Figure 4 and Table I).

Trapezius EMG activity during task C was significantly higher than tasks A and B. Activity during task D was significantly higher than task A (Figure 5 and Table I).

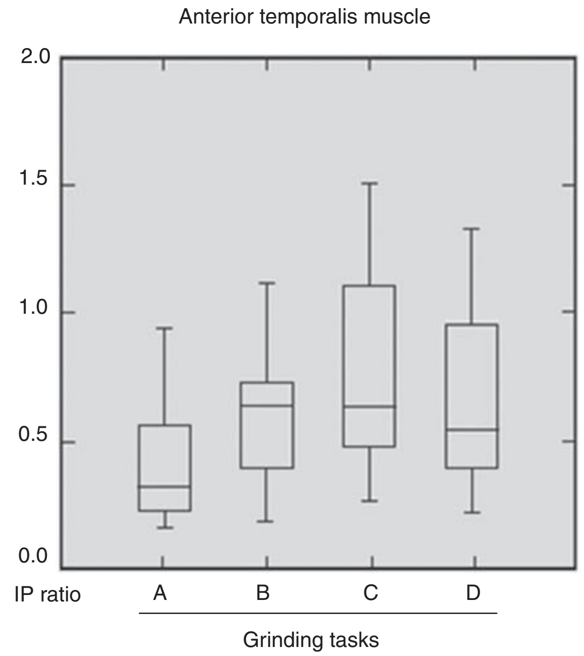

Figure 2. Box plot graph showing median and IQ range of anterior temporalis EMG activity recorded during the following grinding tasks: (A) eccentric grinding from intercuspal position (IP) to protrusive edge-to-edge contact position; (B) concentric grinding from protrusive edge-to-edge contact position to IP; (C) eccentric grinding from IP to the maximum voluntary retrusive position; (D) concentric grinding from the maximum voluntary retrusive position to IP. IP ratio = EMG recorded during each grinding task/EMG recorded during maximum clenching in IP.

Discussion

EMG activity was recorded during awake tooth grinding because it has recently been shown that during wake-time the subjects not only clench but also grind their teeth [16,17].

EMG pattern activity recorded at different tooth grinding jaw tasks in the muscles studied supports the idea that there is a functional link between the masticatory and cervical muscles, probably based on a co-activation mechanism [18,19] and this is in agreement with the concept of neuromuscular integrated function in the CCMU.

The anterior temporalis muscle showed lower EMG activity in task A. This could be the result of the inhibition caused by neuromuscular mechanisms of peripheral origin, mainly from periodontal receptors (lower threshold of anterior teeth) and joint receptors (higher TMJ load).

The major finding is that EMG activity in task C was higher in the anterior temporalis and infrahyoid muscles. This pattern matches, in part, with Berzin's [20] research, who found increased EMG activity in the infrahyoid muscles during retrusive movements of the jaw. It should be noted that this author did not record EMG activity during maximal voluntary tooth grinding, but only during jaw movements in different directions.

Table I. Comparison of EMG activity recorded during tooth grinding tasks studied.

	p-value			
	Anterior temporalis	Suprahyoid	Infrahyoid	Trapezius
Task A vs Task B	0.000 *	0.614 NS	0.082 NS	0.028 NS
Task A vs Task C	0.000 *	0.023 NS	0.000 *	0.000 *
Task A vs Task D	0.000 *	0.719 NS	0.000 *	0.005 *
Task B vs Task C	0.003 *	0.018 NS	0.000 *	0.005 *
Task B vs Task D	0.082 NS	0.829 NS	0.002 *	0.032 NS
Task C vs Task D	0.002 *	0.000 *	0.002 *	0.021 NS

p-values were obtained by Wilcoxon signed-rank sum test; NS, $p \geq 0.0083$; * $p < 0.0083$.

Higher EMG activity observed during task C is probably due to its role in positioning and/or stabilizing the skull, jaw and/or hyoid bone. This could be explained based on the influence of different neuromuscular mechanisms both of peripheral (trigeminal, lingual and cervical afferents) and central (vestibular receptors and visual system) origin, which modulate the discharge of the motor neuron pool controlling the activity of the muscles studied [11,21].

From the point of view of the influence of trigeminal afferents during tooth grinding, it is important to consider those from periodontal, muscles, mucosal, lingual and joint receptors. Tooth grinding during jaw posture task C means a change in the number and location of the tooth contacts, implying a difference in the periodontal area involved, with different density of receptors and mechanosensitivity threshold [22]. It also involves a change in muscle length and therefore in the muscle spindle afferent discharge. In addition, it involves a change in condylar position and joint loading and, therefore, a change in afferent discharge of the joint proprioceptors. It is well known that sensory inputs from low-threshold orofacial proprioceptors such as the muscle spindles [23,24] and mechanoreceptors in the temporomandibular joint [25] are important afferents in the regulation of motor neuron pools, so one would have expected a change in the afferents by changing jaw position, evidenced by a

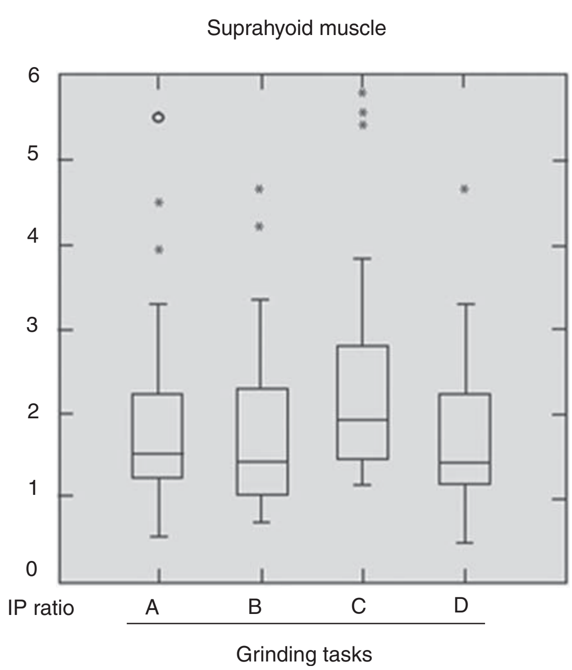

Figure 3. Box plot graph showing median and IQ range of suprahyoid EMG activity recorded during the following grinding tasks: (A) eccentric grinding from intercuspal position (IP) to protrusive edge-to-edge contact position; (B) concentric grinding from protrusive edge-to-edge contact position to IP; (C) eccentric grinding from IP to the maximum voluntary retrusive position; (D) concentric grinding from the maximum voluntary retrusive position to IP. IP ratio = EMG recorded during each grinding task/EMG recorded during maximum clenching in IP.

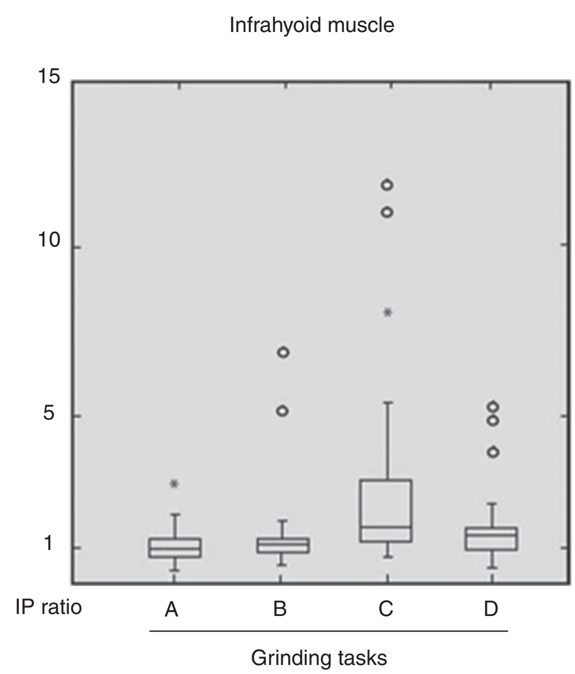

Figure 4. Box plot graph showing median and IQ range of infrahyoid EMG activity recorded during the following grinding tasks: (A) eccentric grinding from intercuspal position (IP) to protrusive edge-to-edge contact position; (B) concentric grinding from protrusive edge-to-edge contact position to IP; (C) eccentric grinding from IP to the maximum voluntary retrusive position; (D) concentric grinding from the maximum voluntary retrusive position to IP. IP ratio = EMG recorded during each grinding task/EMG recorded during maximum clenching in IP.

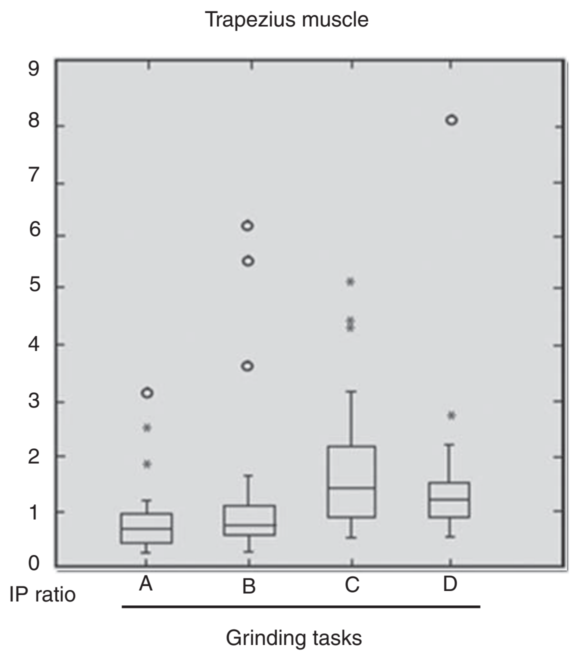

Figure 5. Box plot graph showing median and IQ range of trapezius EMG activity recorded during the following grinding tasks: (A) eccentric grinding from intercuspal position (IP) to protrusive edge-to-edge contact position; (B) concentric grinding from protrusive edge-to-edge contact position to IP; (C) eccentric grinding from IP to the maximum voluntary retrusive position; (D) concentric grinding from the maximum voluntary retrusive position to IP. IP ratio = EMG recorded during each grinding task/EMG recorded during maximum clenching in IP.

change in EMG activity. Recently, Sowman et al. [26] have presented experimental results showing that psychophysical detection of mechanical changes in force within the periodontium is modulated by the dynamic status of the jaw.

Tooth-grinding implies adjusting and maintaining a head-neck posture, which gives the elevator muscles fixed and stable insertion in the skull. It is well known that the tonic neck reflex plays a key role in the achievement of an upright head-neck posture. Kraus [27] suggests that the tonic neck reflex, based on the input of neck proprioceptors, contributes to the achievement of the final and most important head-neck posture. In addition, a closely organized neurophysiologic reflex relationship appears to exist between the tonic neck reflex activity and trigeminal reflex activity [28]. EMG activity output depends not only on the result of the influence of trigeminal input but also on the central neuromechanisms [29]. With respect to the vestibular apparatus, it is well known that it is the receptor detecting head position and changes in space, therefore serving as one of the major organs of equilibrium [30], which could influence the motor neuron pools of the muscles studied. The influence of the visual system must also be considered, because the subjects were asked to keep their eyes open while the EMG recordings were performed. It is well known that this system plays an important role in the perception of head position and in the co-ordination of eye, head and neck movements by influencing the activity of the muscles integrating the CCMU [27].

Greater EMG activity was recorded in task C, which is a rare mandibular movement during tooth grinding but could become important when its frequency, duration and magnitude are enough to exceed the adaptation capability of the individual.

Given the fact that this study was performed in healthy subjects, the EMG results obtained are not necessarily applicable to a group of bruxers with and without jaw muscle pain or a group of patients with myofascial pain.

The major finding of our study is the higher EMG activity observed during eccentric grinding from intercuspal position to the maximum voluntary retrusive position in the anterior temporalis and infrahyoid muscles. This new knowledge can contribute to a better understanding of the physiology of CCMU. The EMG pattern observed suggests a further study to replicate the finding in a sample of patients with bruxism, miofascial pain and temporomandibular disorders.

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Declaration of Interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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