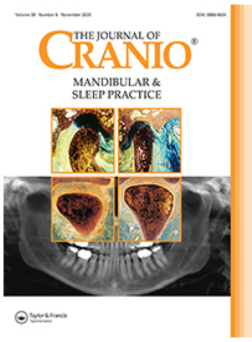

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Awake teeth grinding in participants with canine guidance or group function: Effect on diaphragm EMG activity, heart rate, and oxygen saturation

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OCCLUSION

Awake teeth grinding in participants with canine guidance or group function: Effect on diaphragm EMG activity, heart rate, and oxygen saturation

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ABSTRACT

Objective: To compare the effect of canine guidance or group function on diaphragm activity, heart rate, and oxygen saturation during awake teeth grinding at different body positions.
Methods: Fifty healthy participants, 25 with canine guidance and 25 with group function, were included. Bilateral electromyographic (EMG) recordings of the diaphragm (DIA) during awake teeth grinding were performed in standing, seated upright, and right lateral decubitus positions. Simultaneously, heart rate and oxygen saturation were measured.
Results: EMG activity of the DIA muscle was similar in the working side and non-working side between participants with canine guidance and group function in the different body positions studied. The heart rate and oxygen saturation showed no significant differences between the two groups.
Conclusion: EMG activity of the DIA muscle, the heart rate, and oxygen saturation during teeth grinding are not significantly influenced by the type of laterotrusive occlusal scheme.

KEYWORDS
Canine guidance; group function; teeth grinding; heart rate; oxygen saturation; body position; electromyography

Introduction

Bruxism is a repetitive and involuntary jaw muscle activity characterized by the clenching and/or grinding of the teeth. It presents two circadian rhythms that occur during sleep or wakefulness [1]. It is accepted that this parafunction is mainly originated in the central nervous system [2,3]. Currently, jaw clenching and teeth grinding are prevalent in all age groups, social classes, and cultures [4–8].

Teeth grinding is an activity of major concern to dentists because of its consequences: tooth destruction, breakage of dental restoration or rehabilitation, exacerbation of temporomandibular disorders, induction of headache, and grinding sounds that may interfere with the sleep of family or life partners [6].

The knowledge about oral parafunctional behaviors while subjects are awake is scarce [7–9], and Torisu et al. [10] suggest that more studies should be done using eccentric and concentric grinding as a complement of clenching for a better understanding of the electromyographic (EMG) pattern of the different muscle chains that make up the human body.

EMG recordings during teeth grinding from intercuspal position (IP) to lateral edge-to-edge contact position (eccentric grinding) and vice versa (concentric grinding) have been reported for anterior temporalis muscles [11], masseter muscles [12], sternocleidomastoid muscles [13], supra- and infrahyoid muscles [14,15], between subjects with canine guidance, and with group function. To the authors' knowledge, diaphragm (DIA) EMG recordings during teeth grinding have not been previously reported in subjects with canine guidance or group function. DIA is a respiratory muscle primarily responsible for inspiration in normal individuals [16,17]. The different muscle chains that make up the body are functionally interrelated; the DIA muscle is essential for the survival of the individual, and its activity is closely related to the swallowing and chewing functions. Therefore, it is important to know if DIA activity is influenced by the type of laterotrusive occlusal scheme. This is based on the prevalence of teeth grinding [4,5,18–20], the fact that people grind their teeth in any body position, and on the fact that dentists may modify the

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laterotrusive occlusal scheme during oral rehabilitation procedures or orthodontic treatment.

On the other hand, heart rate and oxygen saturation have been measured in episodes of teeth grinding during sleep [21–26] but not in wakefulness. Therefore, the aim of this study was to compare the effect of teeth grinding in awake subjects with canine guidance or with group function on the bilateral EMG activity of the DIA muscle, heart rate, and oxygen saturation in standing, seated, and right lateral decubitus positions.

Materials and methods

The participants were recruited from the Dental and Medical School of the University of Chile. They volunteered for the study and signed an informed consent form after a detailed explanation of the experimental protocol and the possible risks involved. None of the procedures were dangerous or painful and all were made in accordance with the Helsinki Declaration of 1975, as revised in 1983. The Ethics Committee of the Faculty of Dentistry, University of Chile, approved the study protocol (18/006).

This cross-sectional study included 50 healthy male participants. Recruited participants were male to avoid difficulties with breast size, asymmetry of breasts, and the use of a bra in the female students during the EMG recordings. To be included, all participants had to have complete natural dentition (excluding the third molars), Class I or II canine relationship, bilateral canine guidance or group function, no presence of unilateral or bilateral crossbite, no history of orthodontic treatment within the last 12 months, no history or presence of orofacial pain or craniomandibular-cervical disorders, maxillofacial and/or cervical trauma or fractured teeth, no large restorations that included an incisal edge or one or more cusps, and no cardiovascular, hematological or respiratory diseases. Subjects with Class III canine relationship suffering from environmental allergies or the common cold and those on medication that could affect their muscle activity were excluded.

During the clinical static occlusal exam, Class I canine relationship was defined when the mesial slope of the maxillary canine occluded with the distal slope of the mandibular canine. Class II canine relationship was defined when the distal slope of the mandibular canine occluded posteriorly with the mesial slope of the maxillary canine. During the clinical dynamic occlusal exam, the participants were asked to bite in their habitual IP and then to slide the mandible in right or left lateral excursion to an edge-to-edge contact position. Two clinicians performed all the static and dynamic occlusal examinations. Agreement of both examiners was needed for subject selection. Consistency in the clinical diagnosis across the examiners was high, and when there was no agreement, the subject was excluded. The period during which the examiners selected the sample was continuous and lasted 10 weeks.

The selected sample included the following two groups of 25 participants each, according to their type of laterotrusive occlusal scheme (Table 1):

Table 1. Characteristics of study participants.

Canine guidance							Group function						
Participant	Age	Weight (kg)	Height (m)	Waist (cm)	BMI	Waist/Height	Participant	Age	Weight (kg)	Height (m)	Waist (cm)	BMI	Waist/Height
1	22	65.00	1.66	79.00	23.59	0.48	1	22	72.00	1.74	84.00	23.78	0.48
2	27	65.00	1.71	74.00	22.23	0.43	2	21	66.20	1.73	79.00	22.12	0.46
3	22	103.00	1.85	101.00	30.09	0.55	3	21	77.90	1.85	84.00	22.76	0.45
4	21	90.00	1.76	93.00	29.05	0.53	4	22	56.50	1.67	74.00	20.26	0.44
5	20	72.00	1.69	82.00	25.21	0.49	5	21	74.00	1.68	82.00	26.22	0.49
6	28	59.50	1.63	77.00	22.39	0.47	6	20	66.00	1.72	78.00	22.31	0.45
7	20	66.00	1.73	78.00	22.05	0.45	7	21	82.00	1.75	90.00	26.78	0.51
8	20	64.00	1.62	85.00	24.39	0.52	8	22	77.00	1.78	87.00	24.30	0.49
9	19	64.00	1.75	74.00	20.90	0.42	9	21	75.00	1.70	88.00	25.95	0.52
10	20	67.00	1.86	73.00	19.37	0.39	10	24	69.00	1.76	86.00	22.28	0.49
11	21	57.00	1.65	72.00	20.94	0.44	11	22	73.00	1.70	81.00	25.26	0.48
12	26	72.00	1.73	89.00	24.06	0.51	12	23	52.00	1.69	67.00	18.21	0.40
13	25	73.00	1.73	91.00	24.39	0.53	13	23	79.00	1.87	76.00	22.59	0.41
14	24	93.00	1.79	92.00	29.03	0.51	14	19	61.00	1.70	77.00	21.11	0.45
15	23	75.00	1.83	81.00	22.40	0.44	15	24	80.00	1.72	92.00	27.04	0.53
16	24	73.60	1.79	88.00	22.97	0.49	16	23	90.00	1.83	99.00	26.87	0.54
17	19	71.00	1.77	80.00	22.66	0.45	17	20	85.60	1.86	91.00	24.74	0.49
18	19	91.00	1.90	106.00	25.21	0.56	18	21	72.50	1.71	88.00	24.79	0.51
19	23	84.00	1.80	95.00	25.93	0.53	19	24	69.00	1.72	76.00	23.32	0.44
20	23	70.00	1.73	88.00	23.39	0.51	20	18	70.00	1.67	83.00	25.10	0.50
21	22	107.00	1.75	103.00	34.94	0.59	21	23	65.00	1.75	82.00	21.22	0.47
22	27	73.00	1.65	95.00	26.81	0.58	22	24	72.30	1.70	85.00	25.02	0.50
23	22	73.00	1.74	85.00	24.11	0.49	23	28	60.00	1.73	77.00	20.05	0.45
24	24	73.00	1.73	84.00	24.39	0.49	24	24	61.00	1.69	74.00	21.36	0.44
25	24	84.70	1.68	98.00	30.01	0.58	25	24	67.00	1.65	85.00	24.61	0.52

BMI: Body mass index.

(1) Canine guidance, with only upper and lower canines in contact on the working side and no occlusal contact on the non-working side for both right and left lateral excursion (mean age 22.6 years; range 19 to 28 years);
(2) Group function, with premolars and first molars other than canines in contact on the working side and no contact on the non-working side for both left and right lateral excursions (mean age 22.2 years; range 18 to 28 years).

Electromyography

Bipolar surface electrodes (BioFLEX, BioRESEARCH Associates, Inc., Brown Deer, WI, USA) were placed bilaterally on the DIA muscles (Figure 1). Careful skin abrasion with alcohol was performed to decrease impedance on the right and left sides. The upper electrode was located on the lower edge of the rib cage on a vertical line that passes through the center of the nipple, and the lower electrode 1.5 cm below the upper electrode [27]. A large surface ground electrode (approximately 10.5 cm^2) was attached in the central part of the sternum 3 cm above the xiphoid process. The electrode impedance between both electrodes was measured (Kaise Electric Works, LTD., Model SK-200, Japan); maximal acceptable impedance was 10 KΩ.

EMG activity was recorded using a 2-channel computerized instrument with amplified (Model 7P5B preamplifier, Grass Instrument Co., Quincy, MA, USA) and filtered signals (10 Hz high pass and 2 kHz low pass), with a common mode rejection ratio higher than 100 dB. The output was filtered again (notch frequency of 50 Hz), full-wave rectified and then integrated (time constant of 0.1 s) and recorded online on a computer exclusively dedicated to the acquisition and processing of EMG signals. The EMG signal was acquired at a sample rate of 200 Hz (50 Hz each channel) with a 12 bits A/D converter (MAX191) connected to the computer through an RS-232 port. The system was calibrated before each recording.

EMG activity was recorded while the participant was in the following body positions:

- Standing position, maintaining a stance with the feet 10 cm apart, eyes open, and looking straight ahead. The self-balanced position was obtained by having each subject standing with his visual axis on the horizontal, with no external intervention or modification of his posture [28,29];
- Seated upright position, eyes open and looking straight ahead, with the head unsupported [30], his back supported on the chair, hands on the lap, and feet resting on the floor;
- Right lateral decubitus position, eyes open, with the head, neck, and body horizontally aligned, checked by an external operator located approximately 3 m from the bed [31–33]. The head and neck of each participant were supported by a Sleep Easy Pillow (Interwood Marketing Groups, Ontario, Canada).

The body position sequence was assigned by a random function program (Excel, Microsoft Corporation, USA). Recordings were performed in one single session.

Participants (with canine guidance or group function) underwent three EMG recordings of the bilateral DIA activity while they performed continuous laterotrusive teeth grinding from the IP to the right side (working side) and vice versa, following a metronome at 50 pulses/m. They were asked to grind heavily to the right side while they performed the movement. Each recording

Figure 1. Participant in different body positions studied: standing, seated upright, and right lateral decubitus position.

during teeth grinding lasted 10 s. Additionally, participants underwent three EMG recordings of the bilateral DIA activity while they clenched their teeth as hard as they could in the IP for 10 s. This period was arbitrarily selected to ensure maximum and sustained muscle activity without producing pain and/or muscular fatigue. A 20 s resting period was allowed between each EMG recording. To obtain the average value of each recording, measurements were performed every 0.1 s using a computer program. The mean value of the three curves during teeth grinding as well as during maximal clenching in the IP was obtained for each side, for each body position, and for each participant. Then, activity during teeth grinding was normalized based on the activity recorded during maximal clenching in the IP. The mean value of the three curves obtained during teeth grinding in each body position and for each participant was used for the statistical analysis.

Heart rate and oxygen saturation

Heart rate and oxygen saturation were measured by means of a fingertip pulse oximeter (Choicemmed® model 300-C2, Beijing, China) placed on the index finger of the left hand of the participant after each EMG recording of teeth grinding in each body position. For each participant, the mean value of the three measurements obtained by side (working side or non-working side), body position, heart rate, and oxygen saturation was used for statistical analysis.

The body mass index (BMI) was obtained for each participant, dividing the weight (kg) by the square of the height (m^2). Age, BMI, and index waist (cm)/height (cm) ratio were used to confirm the homogeneity of both groups.

Statistical analysis

Age and index waist (cm)/height (cm) ratio data presented a normal distribution ($p > 0.05$; Shapiro–Wilk test); therefore, a *t*-test for independent samples was used to compare these variables between both groups. BMI and EMG activity presented a non-normal distribution ($p < 0.05$; Shapiro-Wilk test); therefore, a Mann-Whitney *U*-test was used to compare these variables between both groups. A value of $p < 0.05$ was considered significant. The data were analyzed using SPSS software (IBM SPSS Statistics®v21).

Results

The explanatory variables age, BMI, and index waist (cm)/height (cm) ratio (Table 1) showed no significant differences between the groups ($p = 0.552$; $p = 0.388$; $p = 0.114$, respectively).

EMG activity of DIA muscle was similar between participants with canine guidance and group function in the working side (Table 2) as well as in the non-working side (Table 3) in the different body positions studied.

The heart rate (Table 4) and oxygen saturation (Table 5) showed no significant differences between both groups in the different body positions studied.

Discussion

To the authors' knowledge, this is the first study comparing the effect of continuous laterotrusive teeth grinding from the IP to the working side and vice versa (eccentric and concentric grinding, respectively) on bilateral EMG activity of the DIA muscle in awake

Table 2. Comparison of normalized EMG activity in the working side during tooth grinding between participants with canine guidance and group function.

	Canine guidance			Group function			
Body position	25% Percentile	Median	75% Percentile	25% Percentile	Median	75% Percentile	*p*-value
Standing	0.79	0.93	1.12	0.73	0.91	1.04	0.299 NS
Seated upright	0.91	1.01	1.15	0.89	0.96	1.09	0.509 NS
Lateral decubitus	0.91	1.02	1.20	0.79	0.97	1.11	0.522 NS

NS: not significant (Mann-Whitney *U*-test); EMG: Electromyography.

Table 3. Comparison of normalized EMG activity in the non-working side during tooth grinding between participants with canine guidance and group function.

	Canine guidance			Group function			
Body position	25% Percentile	Median	75% Percentile	25% Percentile	Median	75% Percentile	*p*-value
Standing	0.79	0.90	1.00	0.85	0.95	1.07	0.377 NS
Seated upright	0.86	0.97	1.03	0.87	0.95	1.03	0.930 NS
Lateral decubitus	0.85	0.97	1.03	0.88	0.94	1.02	0.734 NS

NS: not significant (Mann-Whitney *U*-test); EMG: Electromyography.

Table 4. Comparison of heart rate during tooth grinding between participants with canine guidance and group function.

	Canine guidance				Group function				
Body position	Median	Mean	[95% Confidence Interval]		Median	Mean	[95% Confidence Interval]		*p*-value
Standing	79.00	79.87	73.80	85.94	75.67	75.67	70.83	80.51	0.388 NS
Seated upright	69.67	73.68	67.81	79.55	69.33	68.81	64.96	72.67	0.467 NS
Lateral decubitus	65.33	66.83	61.73	71.92	66.33	66.49	61.41	71.58	0.846 NS

Table 5. Comparison of oxygen saturation during tooth grinding between participants with canine guidance and group function.

	Canine guidance				Group function				
Body position	Median	Mean	[95% Confidence Interval]		Median	Mean	[95% Confidence Interval]		*p*-value
Standing	98.67	98.43	98.16	98.69	99.00	98.56	98.23	98.89	0.196 NS
Seated upright	99.00	98.44	98.07	98.81	99.00	98.63	98.24	99.01	0.163 NS
Lateral decubitus	99.00	98.65	98.35	98.96	99.00	98.79	98.56	99.01	0.342 NS

healthy participants with canine guidance or group function, without altering their oral environment.

The similar EMG activity observed in the DIA muscle between participants with canine guidance or group function reveals that the influences from the brain stem and cortical areas related to respiration are more powerful than the influences from the receptors of the stomatognathic system on the motor neuron pool that controls the activity of the DIA muscle. This result is relevant from a clinical point of view because it means that when an extensive oral rehabilitation or an orthodontic treatment are being carried out, the type of laterotrusive occlusal scheme does not play a critical role in the EMG activity of the DIA muscle.

EMG activity of the DIA muscle recorded during teeth grinding in awake participants does not correspond to an activity during a bruxism episode, since neither of the participants was diagnosed as having possible, probable, or definitive bruxism [1]; but people frequently grind their teeth [4,5,18–20], whether they are bruxers or not.

It should be emphasized that the results of the present study were obtained in healthy participants, with no history or presence of orofacial pain or craniomandibular-cervical disorders. This consideration is important because Chen et al. [34] observed that the frequency of non-functional tooth contact was approximately four times higher in patients with myogenous facial pain than in healthy subjects. Moreover, Funato et al. [35] found that patients with temporomandibular dysfunction have 3.6 times more non-functional tooth contacts than healthy subjects. Therefore, it could be important to replicate this study in patients with temporomandibular disorders, since upon increase in the frequency of teeth grinding episodes, the EMG activity of the DIA muscle may be different in participants with canine guidance vs. group function.

As far as the authors know, this is the first study of heart rate and oxygen saturation in standing, seated, and lateral decubitus positions during continuous eccentric and concentric teeth grinding in healthy participants with canine guidance or group function. In the present study, in awake participants, no significant differences were found between the two groups. However, some studies have observed that rhythmic masticatory muscle activity/sleep bruxism episodes are related to autonomic cardiac variation such as tachycardia, due to a rise in the activity of the sympathetic nervous system [36–46]. Dumay et al. [24] found that a subgroup of subjects with sleep bruxism had a minor transient hypoxia potentially associated with the onset of rhythmic masticatory muscle activity/sleep bruxism episodes. A decrease in oxygen saturation may trigger a cascade of physiological events that activate the whole body by stimulating the sympathetic system and the respiratory muscles [24]. It has been suggested that a hypoxia event can trigger a whole-body response to address any change in blood oxygen levels to preserve brain and whole-body integrity [25,26].

This study has at least two limitations. First, the subjects examined were only male, which limits the ability to extrapolate these findings to the general population, and second, surface electrodes on the chest could capture electrocardiogram (ECG) and/or activity from neighboring muscles.

Conclusion

EMG activity of the DIA muscle, the heart rate, and oxygen saturation during awake teeth grinding are not significantly influenced by the type of laterotrusive occlusal scheme in healthy participants.

From a clinical point of view, the result of the present study is important because it means that when an extensive therapeutic oral rehabilitation procedure or an orthodontic treatment are being carried out, the type of laterotrusive occlusal scheme does not significantly influence the EMG activity of the diaphragm muscle in healthy males.

Ethics approval

Protocols based on ethical principles that have their origin in the Declaration of Helsinki were used (18/006).

Contributors

S.V., R.M., H.S., M.I.M., C.Z., contributed to conception, design, data acquisition, analysis and interpretation, drafted and critically revised the manuscript; R.B., G.C., N.A.G., A.D.F, contributed to design and data interpretation, drafted and critically revised the manuscript. All authors gave final approval and agreed to be accountable for all aspects of the work.

Disclosure statement

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