Clin Oral Invest (2017) 21:1139–1148
DOI 10.1007/s00784-016-1870-8

ORIGINAL ARTICLE

Frequency of daytime tooth clenching episodes in individuals affected by masticatory muscle pain and pain-free controls during standardized ability tasks

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Received: 29 February 2016 / Accepted: 2 June 2016 / Published online: 9 June 2016

Abstract

Objectives Tooth clenching has been suggested to be related to temporomandibular pain. However, the electromyographic characteristics of daytime clenching episodes have been minimally investigated. This study aimed to analyze the frequency, amplitude, and duration of daytime clenching episodes in patients with masticatory muscle pain and pain-free individuals.

Methods Fifteen women with masticatory muscles myalgia (MP group, mean ± SD age = 26.4 ± 7.6 years) matched for age to 18 pain-free women (CTR group, mean ± SD age = 25.3 ± 2.8 years) were submitted to three different ability tasks (filling out questionnaires for 40 min, reading for 20 min, and playing a videogame for 20 min). The electromyographic activity periods (AP) of the right masseter greater than 10 % (AP10), 20 % (AP20), and 30 % (AP30) of the maximum voluntary contraction were analyzed.

Results The mean frequencies of AP10, AP20, and AP30 were greater in MP than in CTR individuals (all $p < 0.05$). The mean duration of AP10 was higher in MP group than CTR group only while filling out the questionnaires ($p = 0.0033$). CTR group had an increased frequency and duration of AP10 while playing the videogame than while reading a magazine. The ability tasks did not affect the muscle activity in the MP group.

Conclusions Individuals with masticatory muscle pain have an increased frequency of both high and low-intense daytime clenching episodes. The type of ability task affects the frequency and the duration of clenching episodes only in pain-free individuals.

Clinical relevance Clinicians should recognize that the frequency and intensity of daytime clenching are noticeably increased in individuals with masticatory muscle pain in order to better tailor treatment.

Keywords Daytime tooth clenching · Awake bruxism · Temporomandibular disorders · Orofacial pain · Masticatory muscles · Surface electromyography

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Introduction

Temporomandibular disorders (TMD) comprise a set of frequent conditions affecting the masticatory muscles and/or the temporomandibular joints [1, 2]. TMD-related pain is the main symptom driving treatment-seeking, because it can strongly affect daily activities, the psychosocial domain, and quality of life [3, 4]. The etiology of TMD is still debated and controversial, but it is known to be multifactorial. Recent or past trauma, individual anatomic and neuromuscular abnormalities, biopsychosocial and neurobiological factors, potentially adverse oral behaviors, and bruxism may contribute to their establishment [5–8].

Oral parafunction behaviors are daytime activities like gum chewing, teeth clenching, nail/lip/cheek biting, and objects biting, which go beyond physiological functioning such as chewing, swallowing, and talking [9]. They are usually harmless, but, when the forces produced exceed an individual's physiologic structural tolerance, they could result in harmful effects on muscles and joints [7, 10–12] and could be considered as adverse behaviors.

Daytime clenching, i.e., awake bruxism, continues to be the subject of intense discussions within the dental community for its possible relation with TMD pain [13, 14]. Experimental sustained low-level tooth clenching has been shown to induce soreness in elevator jaw muscles in healthy subjects [15, 16]. A significant association between daytime clenching and myofascial pain (MP) of the masticatory muscles was demonstrated by self-reports [7–10] and by objective recordings [17–19]. Finally, the contributing role of oral parafunctions to the onset of TMD has been further supported recently by a large-scale prospective cohort study [14] and by the significant reduction of pain symptoms after habit reversal treatment [20]. Nonetheless, a number of studies have shown a limited contribution [21], the absence of clinically relevant relationships between different types of self-reported parafunctions, including daytime clenching, and TMD-pain complaints [22], and the lack of a correlation with facial pain intensity [23]. Also, other studies, using tooth wear as an indicator for long-term parafunctional behaviors, failed to find a clinically relevant dose–response relationship between clenching and TMD pain [24, 25]. These controversial findings have mainly been related to the technical difficulty in identifying the presence of waking-state oral parafunctions in the natural environment because people are often unaware of their oral habits [9].

Objective and more reliable measurements based on electromyographic assessments should be collected to confirm or deny the possible relation between daytime clenching and TMD pain. Thanks to novel technical advances, surface electromyography (EMG) has become an objective, reliable, and non-invasive technique for evaluating the extent and duration of muscle activity [26]. In controlled experimental conditions, EMG has been shown to be a powerful tool for the clinical evaluation of the jaw elevators, to detect muscle hyper and hypo function, rest position, and fatigue [27], and to distinguish between functional and non-functional oral behaviors [28].

Currently, quantitative and/or qualitative information about the characteristics of daytime clenching episodes are limited [29, 30], and it is not known whether the characteristics of clenching episodes (e.g., frequency, amplitude, and duration) differ between healthy and TMD individuals. Also, it is not clear whether and how certain mental ability tasks affect the frequency of daytime clenching episodes.

The aim of the present study was to assess the frequency, amplitude, and duration of daytime clenching episodes in TMD patients affected with masticatory muscle pain and to compare them to a control group of pain-free individuals while performing standardized mental ability tasks. It was hypothesized that (1) the frequency, amplitude, and duration of daytime clenching episodes differ significantly between TMD and pain-free individuals and that (2) the ability tasks affect the frequency of daytime clenching in both the groups.

Materials and methods

Study participants

The target population was composed of women aged >18 years seeking for a TMD consultation at the Department of Neurosciences, section of Temporomandibular disorders, at the University of Naples, Federico II, Italy. A preliminary screening was performed according to a modified version of the questionnaire TMD-Pain screener [31] (question #1—"In the last 30 days, how long did any pain last in your jaw or temple area on either side? No pain, pain comes and goes, pain is always present) including a 0–100 mm visual analog scale (VAS [32]), where 0 is the lowest pain and 100 the worst pain ever. Individuals who reported to have current pain in the jaw or temple area ≥ 30 mm were considered eligible for the study. A preliminary TMD investigation of these subjects was performed by a single examiner (AM) according to the DC/TMD [33]. Individuals who presented a DC group I diagnosis (myalgia, myofascial pain, myofascial pain with referral) were informed about the possibility of participating in the research, and that this could require about 2 h of their time. Those ones who were willing to participate were included in the study. Exclusion criteria included wearing extended dental fixed or removable prostheses (equal or greater than three teeth), ongoing orthodontic or dental treatment, neurological disorders, habitual intake of drugs affecting the central nervous system or anti-inflammatory drugs, and/or migraine diagnosis at the moment of screening. Concurrent joint click was not considered as further exclusion criterion.

From an initial pool of 40 subjects screened, 18 women suffering from masticatory muscle pain (MP group) were recruited and matched for age to a control group composed of 18 TMD-free individuals (CTR group). The CTR group was recruited in the same period from among individuals accompanying orthodontic patients. The inclusion criterion was the absence of TMD diagnosis according to DC/TMD [33]. Exclusion criteria were similar to those used for the MP group.

Three subjects of the MP group dropped out due to technical reasons. Thus, the final study sample was made of 15 women suffering from masticatory muscle pain (MP group, mean ± SD age = 26.4 ± 7.6 years) matched for age to a control group composed of 18 pain-free individuals (CTR group, mean ± SD age = 25.3 ± 2.8 years). All patients recruited for the study were screened and examined before the experimental phase. Information concerning their diagnosis was immediately provided. They were also told that the treatment options were conservative. On the other hand, specific treatment modalities including strategies for reducing the frequency of oral habits were discussed only after the experimental phase.

Questionnaires

Each subject was asked to complete a set of questionnaires at the beginning of the study. Both groups filled in the Oral Behavior Checklist [34] (OBC), the State–Trait Anxiety Inventory (STAI [35]), and the Somatosensory Amplification Scale (SSAS [36]). The MP group was asked to fill in the DC/TMD symptom questionnaire [33]. The CTR group was asked also to reply to an additional questionnaire concerning general health and employment status. For clinical purposes, patients were also asked to complete the Graded Chronic Pain (GCP) questionnaire of the Research Diagnostic Criteria for Temporomandibular disorders (RDC/TMD [37]).

Pressure pain thresholds

Pressure pain thresholds (PPTs) were assessed with an electronic algometer (Somedic, Sweden) equipped with a rubber tip (surface area 1 cm^2) in order to assess participants' sensitivity to pain. The device was positioned perpendicular to the skin at the selected site and the pressure was increased at 30 kPa/sec by using a visual feedback. The PPT was determined as the point at which the pressure stimulus changed from a sensation of pressure into a sensation of pain [38]. The subject indicated the PPT by pressing a button, which froze the current pressure value on the digital display. The procedure was explained to the subject who was asked to keep the muscles relaxed during the measurements. PPTs were assessed by a single-blind examiner (VD). All measurements were taken at three locations on both right and left side. The measurement sites were selected on each muscle as follows. For the masseter muscle, the site was located midway between the origin and insertion, 1 cm posterior to its anterior boundary. For the temporalis muscle, the site was located on the line from the top edge of the eyebrow to the highest point of the pinna of the ear, 2 cm behind the anterior margin of the muscle as determined by palpating the muscle during voluntary contraction. For the thenar muscle, measurements were made on the skin of the palmar side, on the thenar eminence. The measurements were repeated for a total of four trials at each muscle, with a 1-min interval between trials. The order of measurements was randomized across subjects. While assessing the PPT at masticatory muscles locations, the subject's head was supported by counter pressure from the opposite hand of the operator. PPTs at thenars were measured with hands flat on the table.

Surface EMG recording

A portable EMG device [39] (Bruxoff ®, Orthorizon, Torino, Italy) was used to acquire EMG signals at the right masseter muscle. The reference electrode was placed on the middle point of the clavicle. Disposable bipolar self-adhesive concentric electrodes (Code® 2.0, Spes Medica, Genova, Italy) with a radius of 2 cm and a silver/silver chloride surface were used. The concentric ring systems of the electrodes show higher spatial selectivity with respect to the traditional detection systems and reduce the problem of electrode location because they are insensitive to rotations and reduce EMG cross talk. The electrode was placed along a line going from the mandibular angle to the cantus, about 20 mm above the mandibular angle [40], and recording was performed 5–6 min later.

Before electrode placement, the skin was cleaned and slightly abraded with an abrasive gel (Everi - Spes Medica, Genova, Italy) to diminish impedance, allowing the conductive paste to adequately moisten the skin surface. Maximum voluntary contraction (MVC) in maximum intercuspal position was recorded, asking the subject to clench as hard as possible and to maintain the same level of contraction for 3 s. This test was repeated three consecutive times, separated by 5 s interval. Verbal encouragement was given to the subject during the test. A trial lasting approximately 2 min was performed before starting the definitive recording, in order to assess the correct placement of the electrodes, that was followed by an 80-min EMG recording (see the experimental protocol).

The signals were sampled at 800 Hz, with eight-bit resolution, and stored in the storage drive of the Bruxoff. The EMG channels were filtered between 10 and 400 Hz. Root mean square (RMS) values were computed. The mean RMS value of the three MVC tests was used to calculate activity periods (AP) at 10 % (AP10), 20 % (AP20), and 30 % (AP30) of the MVC, which were considered as the threshold levels able to detect parafunctional activities. All activity periods (AP10, AP20, AP30) were identified and counted by a dedicated software (OTBiolab®, OT Biolettonica, Torino, Italy).

Experimental protocol

The EMG recording was performed in a silent and comfortable room in our clinic. The subject was invited to sit with the head unsupported and was asked to maintain a natural upright position. Only the subject and one investigator (DL) were present in the experimental room. Each subject was told that the EMG assessment had the purpose of monitoring the activity of the jaw muscles, and was asked to switch off her mobile phone, not to speak to the operator during whole experimental recording session, and not to touch electrodes. Chewing gum or candies were strictly forbidden. The EMG activity was recorded for 80 min during three different sessions in which the participant was invited to fill in the questionnaires (described above) for 40 min (task 1), then to read a general interest magazine for 20 min (task 2), and to a play a game session (Arkanoid, Taito, Japan) on a conventional laptop for 20 min (task 3).

Each participant was monitored by one investigator (DL) during the entire experimental phase. DL checked the time for each session. Before starting the EMG recordings, all participants were told that the time for completing the questionnaires was 40 min and received instructions to concentrate on the questions and not to rush. If they finished earlier, they had to check again their replies and start another set of the same questionnaires available on the desk (but in this case, the forms included questions in another order). Therefore, all participants were fully involved in a mental task for 40 min during this session. If they were not able to complete the questionnaire within the 40 min, they had to stop and they were allowed to answer the questionnaire after the EMG recordings.

The order of the tasks was randomly assigned to each participant. The same procedure was used for the CTR group.

Data analysis

The psychophysical measurements were reduced at each time point by computing the mean of the 3 trials obtained at each PPT location, after discarding the first measurement. A partial OBC score (OBC6) was computed by scoring items 3, 4, 5, 10, 12, and 13 of the OBC. This allowed for the assessment of daytime grinding, clenching, pressing, biting, or playing with soft tissue, holding objects between the teeth, and use of chewing gum. Rationale for considering these six items separately is based on these oral parafunctional behaviors being characterized by pressure against soft tissues, objects, or teeth (tooth clenching), while all other items do not (e.g., sustained talking, yawning, hold telephone between the head and shoulders, etc.).

The mean RMS value of the three EMG MVC peaks was computed for each study participant. The individual value retrieved was used to calibrate and scale each participant's entire EMG signal in preparation for the following statistical analysis. Hence, in the calibrated EMG signal, the MVC was the reference unit (namely 100). All the scaled EMG signals greater than 10 were identified as AP10 (>10 % of the MVC), those greater than 20 as AP20 (>20 % of the MVC), and those greater than 30 as AP30 (>30 % of the MVC). The AP10, AP20, and AP30 were identified and counted, and together with their computed duration, were used for the following statistical analysis.

EMG variables (AP10, AP20, and AP30 count and their computed durations) were tested for normality of distribution. When normality was not verified, between groups and within group well performed by non-parametric tests (Mann–Whitney and Kruskal–Wallis tests). Otherwise, the analysis of variance was used. *P* values were adjusted using the Bonferroni method.

A mixed regression model was used to test the association between the independent psychological variables (SSA, Trait and State anxiety) and the primary outcomes, i.e., AP10, AP20, and AP30 count (number of events during the entire EMG session and during each of the three tasks), single duration (Dur—mean duration of single clenching episodes), and cumulative duration (CDur—sum of the duration of all clenching episodes) over the entire experimental phase using logarithmically transformed data. Interaction between study group (fixed factor) and SSA, trait and state Anxiety scores (covariates) were tested and retained in the model when statistically significant.

Between groups comparisons in SSA and STAI (trait and state anxiety), OBC and OBC6 scores were calculated by using *t* test.

The statistical significance was set at $p < 0.05$. SPSS software ver. 20 (IBM Corp, Armonk, NY, US.) was used for running the statistical analysis.

Results

The MP group had 6.1 ± 1.9 pain rated on a VAS scale. According to the graded chronic pain (GCP) classification of the RDC/TMD [37], patients had a characteristic pain intensity (CPI) of 51.4 ± 23.2. Four subjects had GCP grade I, eight grade II, and three grade III.

Descriptive statistics and comparisons between groups (MP vs CTR) for PPT assessments are reported in Table 1. PPT was significantly lower in MP than in CTR group for both left and right anterior temporalis muscles ($p = 0.004$ and $p = 0.010$ respectively) and for the right masseter ($p = 0.007$). No significant differences were found for the thenar muscle.

Descriptive statistics and between groups comparisons for AP10, AP20, and AP30 count, Dur, and CDur for both groups are reported in Table 2. The number of AP10, AP20, and AP30 was significantly greater in MP than CTR individuals (all $p < 0.05$). No significant differences were found between groups with respect to AP durations. The cumulative durations of AP10, AP20, and AP30 were significantly higher in MP than CTR group (all $p < 0.05$). The RMS of the masseter during the MVC was higher in the CTR group (62.3 ± 25.1) than in the MP group (33.8 ± 30.0, $p = 0.002$).

The distribution of the dependent variables within the three tasks for each group and within and between groups

Table 1 Descriptive statistics and between-group comparisons for PPT values (KPa)

	MP		CTR		*p* value
	Mean	SD	Mean	SD	
Left					
Masseter	131.6	49.7	156.9	45.3	0.137
Temporalis	146.8	45.1	197.4	46.8	*0.004*
Right					
Masseter	126.1	37.9	169.2	45.4	*0.007*
Temporalis	154.8	43.6	196.2	42.9	*0.010*
Thenar	303.6	104.7	283.5	71.7	0.521

Italicized data: statistically significant

comparisons are reported in Figs. 1, 2, and 3. Count AP 10, Count AP20, Count AP30 and CDur AP10, CDur AP20, and CDur AP30 were significantly higher in MP than CTR group in all tasks (all $p < 0.05$). Dur AP10 was higher in MP group than CTR group only during the task including questionnaires ($p = 0.0033$). CTR group had a higher Count AP10, Dur AP10, and CDur AP10 while playing the videogame as compared to reading a magazine.

Descriptive statistics and between group differences for STAI, SSAS, OBC, and OBC6 outcomes are reported in Table 3. Trait anxiety was associated to Count AP20 ($F = 4.63$; $p = 0.040$), Count AP30 ($F = 4.90$; $p = 0.035$), CDur AP10 ($F = 4.61$;$p = 0.040$), and CDur AP30 ($F = 4.44$;$p = 0.044$). State anxiety and SSAS were not associated to any of the dependent variables (all $p > 0.05$, data not shown).

OBC total scores were not correlated to the dependent variables, while OBC6 was positively correlated to CDur AP10 ($r = 0.351$, $p = 0.046$).

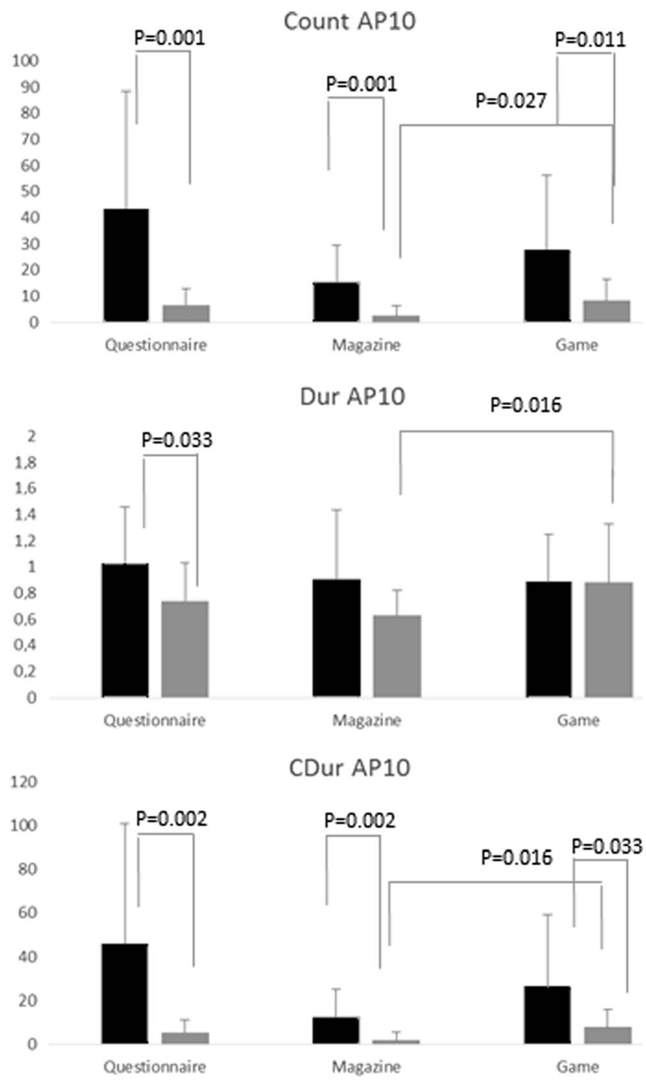

Fig. 1 Distribution of the dependent variables Count AP10 (*number of episodes*), Dur AP10 (*seconds*), and CDur AP10 (*seconds*) within the three tasks for each group (MP—*black*, CTR—*gray*) and within and between group comparisons. The *lines* above the *bars* indicate the standard deviation. Significant differences between and within groups are indicated by *lines* and corresponding *p* values

Table 2 Descriptive statistics and between-group comparisons for EMG outcomes over 80 min recordings for AP10, AP20, and AP30 count (number of events during the entire EMG recording—80 min), single duration (*Dur*—mean duration of single clenching episodes), and cumulative duration (*CDur*—sum of the durations of all clenching episodes)

	MP		CTR		*p* value
	Mean ± SD	Median [IQR]	Mean ± SD	Median [IQR]	
Count AP10	84.9 ± 78.3	49.0 [103.0]	17.8 ± 13.1	17.0 [21.5]	*0.001*
Count AP20	52.6 ± 58.9	38.0 [78.0]	6.8 ± 8.3	4.0 [8.7]	*0.002*
Count AP30	36.9 ± 49.7	13.0 [64.0]	3.7 ± 5.3	1.5 [6.0]	*0.002*
Dur AP10	1.0 ± 0.3	1.0 [0.3]	0.8 ± 0.2	0.7 [0.4]	0.064
Dur AP20	0.8 ± 0.2	0.7 [0.5]	0.7 ± 0.1	0.7 [0.3]	0.241
Dur AP30	0.7 ± 0.2	0.7 [0.4]	0.7 ± 0.3	0.6 [0.3]	0.852
CDur AP10	82.9 ± 91.0	43.5 [103.5]	15.1 ± 13.5	10.5 [23.6]	*0.002*
CDur AP20	45.2 ± 54.2	27.5 [61.0]	5.1 ± 6.7	2.5 [6.7]	*0.002*
CDur AP30	30.4 ± 40.1	7.5 [49.5]	2.6 ± 4.1	1.0 [3.7]	*0.004*

Italicized data: statistically significant

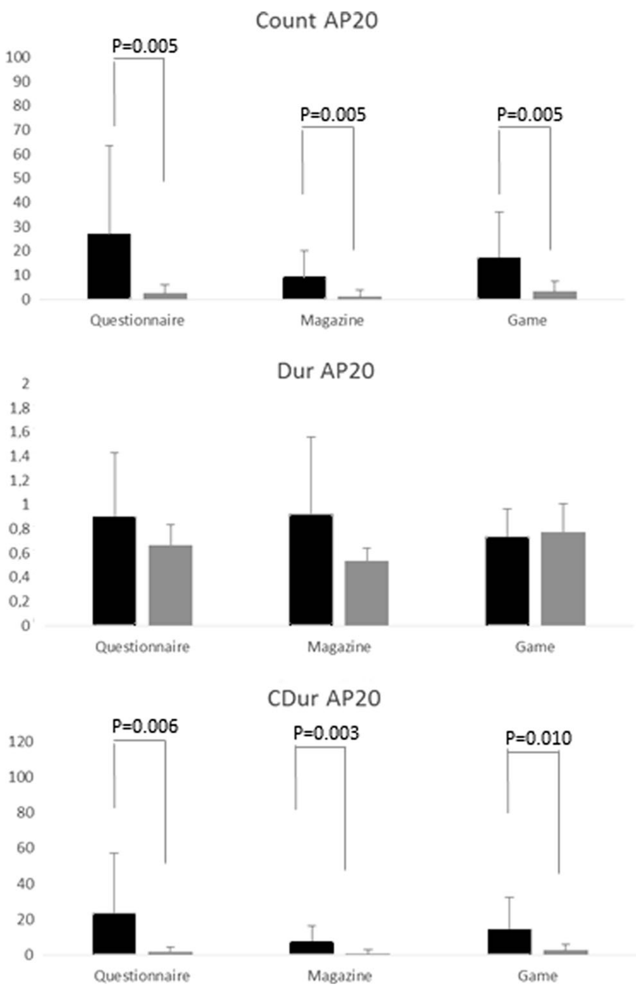

Fig. 2 Distribution of the dependent variables Count AP20 (*number of episodes*), Dur AP20 (*seconds*), and CDur AP20 (*seconds*) within the three tasks for each group (MP—*black*, CTR—*gray*) and within and between group comparisons. The *lines* above the *bars* indicate the standard deviation. Significant differences between and within groups are indicated by lines and corresponding *p* values

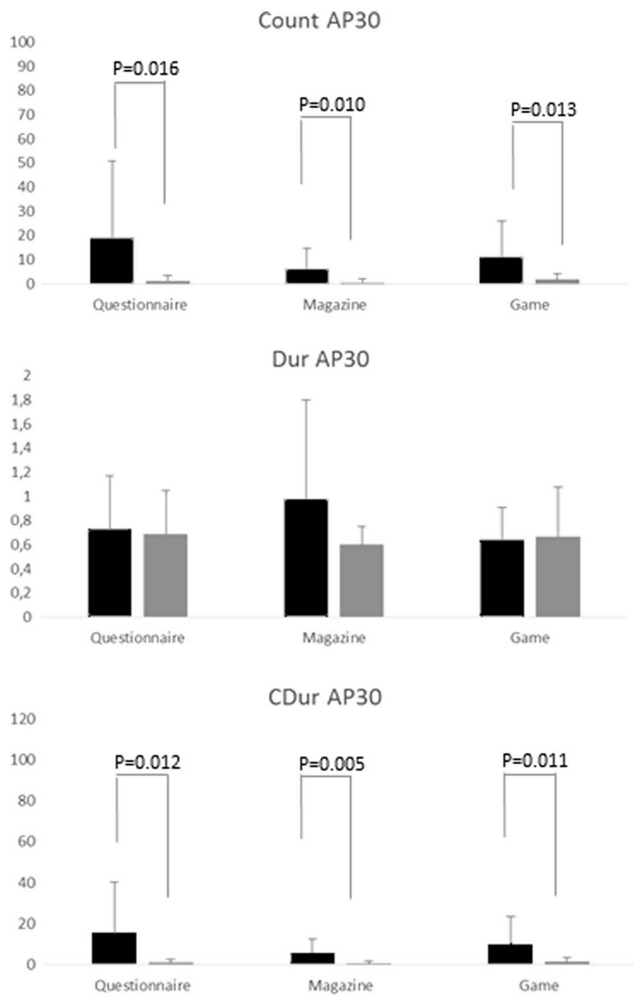

Fig. 3 Distribution of the dependent variables Count AP30 (*number of episodes*), Dur AP30 (*seconds*), and CDur AP30 (*seconds*) within the three tasks for each group (MP—*black*, CTR—*gray*) and within and between group comparisons. The *lines* above the *bars* indicate the standard deviation. Significant differences between and within groups are indicated by lines and corresponding *p* values

Discussion

This study has shown that the frequency of daytime clenching episodes is different between individuals suffering from myofascial pain of the masticatory muscles and healthy pain-free controls, and that certain ability tasks can affect the frequency of daytime clenching episodes only in pain-free individuals. Although daytime clenching is considered a risk for TMD [7, 14], little is known about the specific EMG characteristics of daytime clenching episodes, e.g., about their frequency, duration, and amplitude, and if these features differ between individuals suffering from myofascial pain of the masticatory muscles and healthy controls. A threshold of 30 mm on VAS scale was used to recruit patients with masticatory muscle pain because the smallest detectable difference for actual temporomandibular pain has been suggested to be 28 mm on VAS [41].

Table 3 Descriptive statistics and between-group comparisons for questionnaires outcome

	Group	Mean	SD	*p* value
STAI (state anxiety)	CTR	43.6	3.9	*0.027*
	MP	40.4	4.1	
STAI (trait anxiety)	CTR	44.2	3.8	0.774
	MP	44.6	4.2	
SSAS	CTR	11.5	6.4	0.089
	MP	15.2	5.8	
OBC	CTR	19.4	9.1	*0.001*
	MP	32.2	10.1	
OBC6	CTR	4.9	2.8	*0.004*
	MP	8.8	4.3	

Italicized data: statistically significant

STAI state and trait anxiety, *SSAS* somatosensory amplification scores, *OBC* oral behavior checklist—21 items, *OBC6* oral behavior checklist—6 items

The possible relation between clenching and masticatory muscle pain has been tested in several studies, which showed that experimental low-level clenching tasks are associated with muscular soreness and fatigue, leading to TMD-pain-like symptoms [16, 42], that experimental high-level clenching is not related to long-lasting pain of the masticatory muscles [16, 43] and that a delayed-onset of masticatory muscular soreness (DOMS) and a temporary diagnosis of myofascial pain occur in subjects performing bouts of eccentric and concentric jaw muscle contractions with different intensities [12].

The results of the present study reveal that individuals with myofascial pain of the masticatory muscles present higher counts of diurnal masseter activity periods (APs) than controls. This result is in agreement with previous reports showing that the frequency of non-functional tooth contacts is higher in TMD than in TMD-free individuals [17, 30, 44] and that daytime clenching and oral parafunctions are more frequent in subjects with MP diagnosis [7, 10, 14, 15]. MP individuals had an about five times higher count of clenching episodes as compared to TMD-free individuals, when examining all the episodes greater than the 10 % of MVC. This ratio is even higher (amounting to approximately ten times) when considering very intense (greater than 30 % of MVC) clenching episodes. Interestingly, MP individuals showed approximately 4 % of the clenching episodes within 10–20 % of the maximum voluntary contraction, and the more intense clenching episodes (AP30) amounted to approximately 43 % of the recordings. While examining the CTR group, it was found that approximately 41 % of the clenching episodes were within 10–20 % of the MVC, while the more intense clenching episodes (AP30) were only 21 % of the recordings. Moreover, the cumulative duration of the AP episodes was higher in MP group than CTR for AP10 clenching episodes (2 % of the entire experiment in MP group and 0.3 % in the CTR group). All these data suggest that MP individuals show a high frequency of tooth clenching episodes of different intensities and support the hypothesis that MP might be a manifestation of muscle overload due to an alternate pattern of high- and low-level contraction episodes. It can be hypothesized that the metabolic demand of such muscular exercise may be not satisfied in MP patients, thus leading to muscular fatigue and pain. Indeed, it has been shown that low levels (5 %) of maximum voluntary contraction can produce a clear hemodynamic response in masticatory muscles [45], but sufficiency of blood flow to maintain muscle fiber homeostasis is less when the rate of metabolic turnover is greater [46]. In a recent study involving healthy subjects, delayed onset muscular soreness (DOMS) was determined following concentric and eccentric muscle contractions of different intensities [12]. The authors suggested that pain probably resulted from of an accumulation of metabolites within the muscles because of an obstruction of the muscles' blood flow during the exercise. However, further studies with specific methodologies are needed to test whether these mechanisms might have contributed to the onset of masticatory muscle pain in the MP group.

The greater extent of parafunctional behaviors present in the MP group than in the CTR group is further supported by the OBC6 and OBC scores, which were higher in the MP group than CTR. Interestingly, only the shortened version of OBC, namely OBC6, was correlated to the count of episodes, suggesting that OBC6 might be sensitive do detect daytime tooth clenching episodes.

For this study, participants were submitted to different ability tasks in which mental, practical, and both mental and practical abilities were needed. A significant effect of the ability task (questionnaire, reading a magazine, and playing a videogame) on daytime tooth clenching was found only in CTR group, in which it was found that the count, the duration, and the cumulative duration of episodes >10%MVC (AP10) were higher while playing a videogame. On the contrary, the frequency of clenching episodes in the MP group was not affected throughout all the experimental tasks. Hence, it is likely that the progress of time and a practical ability task (i.e., playing a videogame) affected the occurrence of clenching episodes and muscular activity of the CTR group but not of the MP group, who continued to show frequent clenching behaviors independently from the task, as reported previously [18]. The EMG response found in the CTR group (i.e., higher frequency and duration of clenching episodes while playing the videogame as compared to reading a magazine) is confirmed by some authors who report acute changes (i.e., relative increase) in myoelectric activity of masseter and temporalis muscle with stressful conditions [47, 48]. It is somehow likely that clenching episodes in the CTR group were triggered by the videogame, which requires both a mental and practical ability.

Contrary to a previous report [19], we did not find between groups differences in trait anxiety. This is in agreement to Giannakopoulos and coworkers who reported that individuals with facial pain did not present increased anxiety as compared to the general population [49].

Nonetheless, the association found between trait anxiety and the dependent variables suggests that anxiety played a major role in influencing the intensity and the frequency of clenching episodes in some individuals. Also, although not significant, MP individuals had slightly higher levels of somatosensory amplification, a characteristic related to bodily and occlusal hypervigilance. The concept of somatosensory amplification has been applied to the chronic pain population to explain how maladaptive cognitions may lead to heightened pain perception [50]. However, this factor was not associated with the dependent variables in the current experiment. Interestingly, state anxiety was greater in the CTR group than in the MP group. Although both groups received similar information concerning the experimental procedure, it is likely that the EMG recording was felt more emotionally by pain-free people, who were worried and nervous because not comfortable with medical and laboratory evaluations, while it is possible that the information received by the MP patients during the clinical examination contributed to decrease their state anxiety [51]. The PPT values were within the ranges previously found for TMD and TMD-free individuals. As expected, MP group had lower PPTs at the masseter and temporalis than subjects in the CTR group [18, 52, 53]. Nonetheless, the difference at the left masseter was not statistically significant. This is likely the result of a greater variation of the measurements at this site in the MP group. Moreover, the absence of between groups difference in PPT measurements at the thenar eminence let us hypothesize that central sensitization phenomena did not affect the current findings [54, 55].

This study has some limitations. First, for this study, we recruited only individuals with actual masticatory muscle pain. Therefore, we cannot draw conclusions about individuals with a history of temporomandibular pain and/or with recurrent pain. Second, the short duration of the experiment does not allow inferring about the relation between daytime clenching and the intensity of masticatory muscle pain. Third, the recordings obtained may be contaminated by artifacts (e.g., due to movements of the electrodes). Video recordings could have addressed this limitation. However, the distribution of these artifacts is likely to be similar between groups and across the conditions and therefore should not have influenced the results. In addition, it might be argued that the initial MVC trials may have acted as artificial stressors with a different impact on the EMG signal of both groups. But, since an interval of approximately 5 min was present between the MVC recordings and the experimental sessions, it can be hypothesized that the MVC trials had a minimal impact on the EMG recordings. Finally, the EMG recordings do not allow distinguishing functional (e.g., swallowing) from nonfunctional masseter contractions. To our knowledge, the frequency of swallowing might be affected by systemic, including hormonal, and oral conditions as well as by age [56]. In this study, both groups were not affected by medical conditions, were not using drugs affecting the frequency of swallowing and the salivary pattern, and were matched by age. Finally, it has been shown that the number of functional tooth contacts (including swallowing) does not differ between TMD patients and healthy subjects [17, 57, 58]. Therefore, it could be assumed that swallowing did not affect the differences found between groups.

Conclusions

Individuals affected with masticatory muscle pain present a greater frequency of daytime clenching episodes than pain-free individuals during standardized mental and practical ability tasks. The type of ability task does not affect the frequency and the duration of clenching episodes in myofascial pain patients. Conversely, pain-free individuals are more sensitive to the tasks in which both mental and practical skills are needed (playing a videogame) and increased the frequency of the clenching episodes.

Acknowledgments The authors thank Dr. Andrea Bottin and Dr. Alessio Bocci for their technical assistance and Dr. Paolo Chiodini for statistical advice.

Compliance with ethical standards

Conflict of interest Dr. Tommaso Castroflorio was involved in the technical development of the Bruxoff Device.

Funding This study was supported by the network of excellence STRAIN (Regione Campania) at the University of Naples Federico II, Italy, through a research fellowship.

Informed consent All participants gave their informed consent prior to the inclusion in the study.

Ethical approval This clinical investigation was reviewed by the Ethics Committee of the University of Naples Federico II.

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