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Effects of low-intensity contractions of different craniofacial muscles in healthy participants – an experimental cross-over study

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Abbreviations:

Jaw: jaw-closing

O-oris: orbicularis oris

O-oculi: orbicularis oculi

NRS: Numeric Rating Scale

ANOVAs: analyses of variance

TMD: Temporomandibular Disorders

TTH: tension-type headache

DOMS: delayed onset muscle soreness

MVOBF: maximal voluntary occlusal-bite force

ICHD-Ⅲ: International Classification of Headache Disorders

DC/TMD: Diagnostic Criteria for Temporomandibular Disorders

MVCF: maximal voluntary contraction force

MPQ: McGill Pain Questionnaire

PRI: Pain Rating Index

SD: standard deviation

IQR: interquartile range

Abstract

Aim: Repetitive jaw-muscle activity characterized by clenching or grinding of the teeth and/or by bracing or thrusting of the mandible, i.e. bruxism, is traditionally linked to pain and unpleasantness in the active muscles. The aim of this study was to investigate the effects of standardized craniofacial muscle contractions on perceived symptoms. **Materials and Methods:** Sixteen healthy volunteers performed six 5-minute bouts of 20% maximal voluntary contraction task of the jaw-closing (Jaw), the orbicularis-oris (O-oris), and the orbicularis-oculi (O-oculi) muscles. Participants rated their perceived pain, unpleasantness, fatigue, and mental stress levels before, during, and after the contraction tasks on 0-10 Numeric Rating Scales (NRS). Each muscle contraction task (= one session) was separated by at least one week and the order of the sessions was randomised in each subject. **Results:** All muscle contraction tasks evoked significant increases in NRS scores of pain (mean ± SD: Jaw; 3.8 ± 2.7, O-oris; 1.9 ± 2.2, O-oculi; 1.4 ± 1.3, $P < .014$), unpleasantness (Jaw; 4.1 ± 2.5, O-oris; 2.1 ± 1.9, O-oculi; 2.9 ± 1.8, $P < .001$), fatigue (Jaw; 5.8 ± 2.0, O-oris; 3.2 ± 2.3, O-oculi; 3.6 ± 1.9, $P < .001$), and mental stress (Jaw; 4.1 ± 2.1, O-oris; 2.2 ± 2.7, O-oculi; 2.9 ± 2.2, $P < .001$). The Jaw contractions were associated with higher NRS scores compared with the O-oris and the O-oculi contractions ($P < .005$) without differences between the O-oris and the O-oculi ($P > .063$). All symptoms disappeared within one day ($P > .469$).

Conclusions: The results showed that submaximal static contractions of different craniofacial muscle groups could evoke transient, mild to moderate levels of muscle pain and fatigue and mental conditions. The fatigue resistance may differ between different muscle groups. Further studies are warranted to better understand the contribution of specific craniofacial muscle groups for the characteristic presentation of musculoskeletal pain conditions in the head. (311 words)

ICMJE: The registration number and name of the trial registry

Introduction

Temporomandibular disorders (TMD) and tension-type headaches (TTH) are frequently encountered craniofacial pain conditions [1] with overlapping clinical presentations and significant impact on quality of life [2]. The craniofacial muscles are suspected to be involved in the pathophysiology and both peripheral and central sensitization as well as impaired endogenous inhibitory controls are implicated in the development and the maintenance of the pain [3, 4]. Nevertheless, the triggering causes or events leading to such neuroplastic changes in the trigeminal and cervical parts of the nociceptive system have not yet been convincingly demonstrated.

Continued contractions of craniofacial muscles, e.g. the frontalis or temporalis muscles, have been linked to TTH [5]. The suggested etiology of myofascial TMD pain in the jaw muscles has been that intense jaw-muscle activities could lead to muscle fatigue and pain. This is seen in limb muscles during 24 - 48 hours after eccentric muscle contractions [6], and is well known as delayed onset muscle soreness (DOMS) [7, 8]. Armstrong et al. (1991) suggested that eccentric muscle exercise damage and break down muscle fibres [9]. Local muscle inflammation may then occur, causing sensitization of primary afferent nerve fibers [10, 11]. Other features of DOMS besides fatigue and pain are allodynia, hyperalgesia, and edema and the curious observation that vibration at 80 Hz significantly increases perceived pain in a muscle with DOMS [12-14]. The DOMS theory has been applied to the jaw-closing muscles by the use of different types of experimental contractions performed in humans in order to evoke myofascial pain in the jaw-muscles [7-9]. For tooth grinding, Christensen (1971) first investigated the effect of experimental tooth grinding on healthy individuals and reported long-lasting jaw-muscle pain [15]. Arima et al. (1999) made the first attempt to induce jaw-muscle pain by a standardized tooth-grinding exercise [16]. For tooth clenching, some studies have used short-time clenching at submaximal level of maximal-voluntary occlusal-bite force (MVOBF) [16-23]. Svensson et al. (1996) made the first attempt to evoke orofacial muscle pain by standardized experimental tooth clenching and reported that the tooth-clenching procedure failed to induce a progressive increase in masticatory muscle pain [17]. Some studies reported that low-level tooth-clenching tasks (≤ 10% MVOBF) do not produce long-lasting pain and fatigue [18, 22]. However, perceived levels of fatigue were significantly higher after low-level tooth-clenching tasks than after high-level tooth-clenching tasks (≥ 15% MVOBF) [17]. Takeuchi et al. (2015) recently reported that prolonged (two hours) and low-level (10% MVOBF) tooth-clenching evoked short-lived TMD-like pain, but the tasks could not induce longer lasting jaw-muscle or temporomandibular joint pain [24].

Furthermore, the International Classification of Headache Disorders (ICHD-III) and the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) have recently identified headache and facial pain attributed to TMD [1, 25]. It has also been reported that oral habits, such as teeth clenching, may be related to migraine and TTH [26].

The aim of this study was to investigate and compare, in a randomized and controlled cross-over clinical trial in healthy participants, the effects of continuous low-level contractions of different craniofacial muscles groups on subjective ratings of craniofacial symptoms. We hypothesized that (1) perceived levels of pain, unpleasantness, fatigue, and mental stress increased after experimental craniofacial muscle contractions, and (2) the subjective symptoms from contractions of the jaw-closing, the orbicularis-oris, and the orbicularis-oculi muscles would be different from each other.

Materials and Methods

Participants

Seven men (25.7 ± 1.4 years) and nine women (24.9 ± 2.3 years) participated in this study. All participants were healthy and students or staff recruited at Aarhus University. Exclusion criteria (based on self-report and inspection at the laboratory) were: (1) younger than 18 years of age; (2) less than 24 teeth in complete dental arches; (3) craniofacial pain complaints or other pain conditions; (4) systemic inflammatory connective tissue diseases e.g. rheumatoid arthritis; (5) consumption of analgesics, e.g. paracetamol, non-steroidal anti-inflammatory drugs, salicylate drugs, or opioids, or other medication that would influence pain perception e.g. antidepressants and antiepileptic drugs; (6) pregnancy; and (7) severe skeletal malocclusions. All participants received both written and oral information about the experiment before they signed an informed consent document and they were monetary compensated for their participation.

Experimental Study Design

The participants performed six 5-minutes bouts, a total of 30 minutes standardized experimental muscle contractions of three different craniofacial muscle groups, i.e.

jaw-closing (Jaw), orbicularis oris (O-oris), and orbicularis oculi (O-oculi) muscles; one muscle group were tested per session (Fig. 1). The order of the three sessions was randomized in each participant, and the sessions were separated by at least one week (= wash out period). Before, during, and after the standardized experimental muscle contractions, the participants were asked to report their perceived levels of pain, unpleasantness, fatigue, and mental stress (Fig. 1). Eight out of the 16 participants, whom were randomly selected, joined an additional fourth session as a control (Control) in which no contractions were performed. All sessions were conducted at the laboratory of the Section of Orofacial Pain and Jaw Function, Department of Dentistry and Oral Health, Aarhus University, Denmark. All data were collected by the same female investigator (T.I.). The experimental protocol was approved by the Central Denmark Region Committees on Biomedical Research Ethics (No. 20110101) and the study was conducted in accordance with the World Medical Association Declaration of Helsinki and the experiments were conducted in 2014.

Standardized Experimental Muscle Contractions

First, maximal voluntary contraction force (MVCF) in each muscle group was measured with a force meter (Aalborg University, Denmark). The force transducer was coated with a 2 mm thick layer of self-curing acrylic resin. For the Jaw contraction task, participants held the center of the force transducer between the most posterior molars on the right side (Fig. 2: a1, a2). For the O-oris contraction task, participants held the force transducer between the lips. It was additionally coated with a customized silicone impression template (President putty, Coltene, Switzerland) shaped to fit the upper and lower lips and thereby minimized the forces from other craniofacial muscles (Fig. 2: b1, b2) [27]. All 16 participants used the same silicone template for this O-oris contraction task. The silicone template was disinfected between sessions with an alcohol prep pad and covered by cellophane wrap prior to use. For the O-oculi contraction task, the participants held the silicone coated force transducer anterior to the dominant hand side eye orbit. The silicone was customized individually to fit the participant prior to the experimental session (Fig. 2: c1, c2). All participants practiced the tasks so they could control the muscle contraction and force meter before the data collection started. MVCF was performed for 2-3 seconds and the peak force level was assessed. The examiner verbally encouraged the participants to perform the maximum contraction. The recording was repeated for three times and the values were averaged and set as the MVCF before the experimental contraction task (Baseline) [28]. The submaximal MVCF was then calculated and used for the standardized experimental muscle contraction tasks using visual feedback from the force transducer display to obtain the correct level of force. The contraction level was set at 20% [22, 23] of MVCF in accordance with several studies on e.g. jaw-muscle pain and symptoms. The MVCF recordings were performed again after the completion of the contraction task (Immediately after).

Pain, Unpleasantness, Fatigue, and Mental Stress Levels

Numeric Rating Scales (NRS), McGill Pain Questionnaire (MPQ) with Pain Rating Index (PRI), and Drawing of Perceived Pain Area were used for assessment of pain, unpleasantness, fatigue, and mental stress levels (Fig. 1).

Numeric Rating Scales

Four 11-point NRS were administered to the participants at Baseline, immediately after each 5-minutes contraction task (at rest: Period 1-5), and Immediately after, one (1 h), 24 (24 h), and 48 hours (48 h) after the last contraction task (Fig. 1). Levels of pain, unpleasantness, fatigue, and perceived mental stress intensity with 0 corresponding to "no pain / unpleasantness / fatigue / stress at all" and 10 to "the worst pain / unpleasantness / fatigue / stress imaginable" were obtained [29-31]. The participants were carefully explained the definition of pain, unpleasantness, fatigue, and mental stress in order to clearly differentiate the terms and meanings.

McGill Pain Questionnaire and Pain Rating Index

The participants were asked to fill out the MPQ to describe their pain sensation from a list of words, which fall into four groups: sensory, effective, evaluative, and miscellaneous [32]. A total PRI was subsequently calculated. Participants completed MPQ at Baseline, Immediately after, 1 h, 24 h, and 48 h (Fig. 1).

Drawing of Perceived Pain Area

Participants marked the spatial extent of their perceived pain on an anatomical drawing of the head from the lateral and frontal view, the oral cavity (intraoral view), and on a whole body perspective. Subsequently, all drawings were digitized (Sigma Scan Pro 4.01.003) to obtain a quantitative measure of the perceived pain area (arbitrary units) that included potential referred pain area [33, 34]. The drawings of the experimentally evoked pain areas were assessed at Baseline, Immediately after, 1 h, 24 h, and 48 h (Fig. 1).

Statistical Analyses

NRS scores (absolute values of pain, unpleasantness, fatigue, and mental stress) were tested with the use of analyses of variance (ANOVAs) with session (Jaw, O-oris, O-oculi, and

Control) and time (Baseline, Period 1-5, Immediately after, 1 h, 24 h, and 48 h) as repeated measurement factors. MPQ, total PRI, and Drawing of Perceived Pain Area were analysed with ANOVAs with session (Jaw, O-oris, O-oculi, and Control) and time (Baseline, Immediately after, 1 h, 24 h, and 48 h) as repeated measurement factors. The study was performed in a cross-over manner (paired data) and the participants acted as their own controls. Sample size was based on a 5% risk of type I and 20% risk of type II errors, an estimated intra-individual variation of 20%, and the possibility to detect a minimal relevant difference of 20% in the pain level. Thus, a minimum of 15 participants should be included. When appropriate, the Tukey HSD test was used for post-hoc analyses. Results are presented as mean ± standard deviation (SD). Values of $P < .050$ were considered statistically significant. All analyses were performed by commercial software (STATISTICA, StatSoft Inc., USA). All data from current study has never been published in elsewhere.

Results

All participants completed the study and no side effects except the expected muscle symptoms were observed. There were no missing data in the study.

Maximal Voluntary Contraction Force

Table 1 shows the mean MVCF of Jaw, O-oris, and O-oculi muscles at Baseline and Immediately after. There were no major changes of the MVCF in any of the muscles groups by the experimental contractions ($P > .056$).

Numeric Rating Scales

The overall analysis showed that all pain, unpleasantness, fatigue, and mental stress NRS scores demonstrated significant main effects of both session (ANOVA: $P < .001$) and time (ANOVA: $P < .001$, Fig. 3).

In the Jaw session, NRS scores of pain, unpleasantness, fatigue, and mental stress were increased at all time points between Period 1 (NRS = 3.1 ± 2.1, 3.4 ± 2.2, 3.7 ± 1.7, and 2.9 ± 2.1, respectively) to Immediately after (NRS = 3.8 ± 2.7, 4.1 ± 2.5, 5.8 ± 2.0, and 4.1 ± 2.2, respectively) compared with Baseline (all parameters, NRS = 0, Tukey: $P < .001$). In the O-oris session, NRS scores of pain at Immediately after (NRS = 1.9 ± 2.2, Tukey: $P = .014$), NRS scores of unpleasantness and fatigue at Period 4 (NRS = 1.4 ± 1.4 and 2.6 ± 1.9, respectively) to Immediately after (NRS = 2.1 ± 1.9 and 3.2 ± 2.3, respectively, Tukey: *P*

< .014), and mental stress at Period 3 (NRS = 1.6 ± 1.8) to Immediately after (NRS = 2.2 ± 2.7, Tukey: $P < .034$) were significantly increased at these time points compared with Baseline (all parameters, NRS = 0). In the O-oculi session, NRS scores of pain at Period 4 (NRS = 1.5 ± 1.4) to Immediately after (NRS = 1.4 ± 1.3, Tukey: $P < .001$), NRS scores of unpleasantness, fatigue, and mental stress at Period 1 (NRS = 1.8 ± 1.2, 2.1 ± 1.5, and 2.0 ± 1.7, respectively) to Immediately after (NRS = 2.9 ± 1.8, 3.6 ± 1.9, and 2.9 ± 2.2, respectively, Tukey: $P < .001$) were significantly increased at these time points compared with Baseline (all parameters, NRS = 0). All symptoms disappeared within one hour after the experiment.

Jaw contractions evoked significantly higher NRS pain, unpleasantness, fatigue, and mental stress scores at all time points between Period 1 to Immediately after compared with O-oris (Tukey: $P < .001$). Jaw contractions also resulted in significantly higher NRS scores of pain (Tukey: $P < .001$), unpleasantness (Tukey: $P < .005$), and fatigue (Tukey: $P < .001$) at Period 1 to Immediately after, and mental stress at Period 3 compared with O-oculi (Tukey: $P = .005$). O-oculi contractions evoked higher NRS scores of mental stress at Period 1 compared with O-oris (Tukey: $P = .027$), otherwise there were no differences in any of the other NRS scores at any time point from contractions of these two muscles groups (Tukey: $P > .063$).

McGill Pain Questionnaire and Pain Rating Index

The participants used several words from the McGill Pain Questionnaire (MPQ) to describe their perceived pain and craniofacial symptoms. The most frequently used words by at least 30% of the participants are presented in Table 2. The mean sensory, affective, evaluative, miscellaneous and total Pain Rating Index (PRI) scores are presented in Table 3. At Baseline none of the participants reported any pain. The mean total PRI score showed significant effects of both session (ANOVA: $P = .029$) and time (ANOVA: $P < .001$). A post-hoc analysis revealed that the mean total PRI score in the Jaw and the O-oculi sessions were significantly higher than in the control session (Tukey: $P < .001$).

Drawing of Perceived Pain Area

When the participants were asked to draw the spatial extent of the perceived pain, the pain occurred on both sides of the face from a lateral, intraoral, and frontal perspective (Fig. 4 and Table 4). In the Jaw session, 14 out of 16 participants reported pain on the lateral aspect of the face Immediately after contractions. There were significant main effect of session and time (ANOVA: $P < .001$). In the O-oris and the O-oculi sessions, 11 of 16 participants reported pain on the lateral aspect of the face Immediately after contractions. The post-hoc analysis revealed that Immediately after contractions on the lateral aspect of the face in the

Jaw session, the average pain drawing area was significantly larger than the control session (Tukey: $P < .001$). There was no main effect of session (ANOVA: $P > .099$), but a significant main effect of time (ANOVA: $P < .004$) on the frontal and the intraoral pain drawings. The post-hoc analysis revealed that Immediately after contractions on the frontal part of the face in the O-oris session, the average pain drawing area was significantly larger than the control session (Tukey: $P < .001$). The pain distribution assessed on the drawings differed markedly in terms of location without any significant overlaps (Fig. 4).

Head pain occurred in 6 out of 16 participants in the Jaw session, in 1 out of 16 participants in the O-oris session, and in 5 out of 16 participants in the O-oculi session (Fig. 4), however, it disappeared within one hour after a session end except for one participant (in a Jaw session) in which the head pain disappeared within one day.

Discussion

The primary findings of this study were that (1) low-level and continuous contractions of jaw-closing, orbicularis-oris, and orbicularis-oculi muscle groups caused pain, unpleasantness, fatigue, and mental stress symptoms but with distinctly different intensities and characteristics, and (2) it seems unlikely that delayed onset muscle soreness (DOMS) can explain these findings in the craniofacial muscles.

The mean maximum voluntary contractions force of the jaw-closing muscles at baseline (306.0 ± 33.3 N) was by far the highest force of the three muscles groups (orbicularis-oris: 6.9 ± 1.0 N and orbicularis-oculi: 1.1 ± 0.1 N). This is the first report of the maximum force of voluntary contraction from both the orbicularis-oris and the orbicularis-oculi muscle groups. The difference in contraction force might be due to various factors such as these facial muscles do not act on a lever or tendon, there might be individual variation in the ability to produce a strong contraction, and also the orbicularis muscles may be thinner and have a different composition of muscle fibers [35].

The low-level and continuous contractions were adopted in this study to produce "low-frequency fatigue", which can typically be seen in limb muscles especially affecting the fast-twitch type II fibers. The present standardized muscle contractions evoked significant levels of muscle pain and fatigue in all jaw-closing, orbicularis-oris, and orbicularis-oculi muscle groups, however, the craniofacial symptoms disappeared within 24 hours after the exercises in all muscles without decreased force output (Table 1). This means that the current experimental muscle exercises did not cause either “metabolic fatigue” or “low-frequency fatigue” which is typical in DOMS. One possibility is that jaw-closing muscles are originally fatigue resistant due to the muscle twitch type (mostly slow-twitch type I) [36], and orbicularis-oris and oculi-muscles (mostly fast twitch type II) [37-39] could be converted to fatigue resistant (fast twitch type IIA) by the normal and daily facial appearance and muscle contractions throughout the life. Another possibility is that all three contractions were basically concentric contractions and therefore less prone to develop DOMS. Although there is a report that concentric and eccentric muscle contractions such as open-close movements can provoke symptoms of DOMS in the jaw-closing muscles [40], this point could be considered as a limitation of the study. There is also a report that it does not seem that experimental tooth-clenching is directly related to DOMS as traditionally described for limb muscles, since the current results do not follow the time course characteristics of DOMS as previously described [23].

An interesting finding in the present study was that some participants reported pain not localized around the contraction region. The experimental muscles in the present study were the “jaw-closing”, the “orbicularis oris”, and the “orbicularis oculi”, and these muscles work in conjunction with other muscles, i.e. craniofacial muscle “groups”. Thus, the experimental craniofacial muscle group contractions evoked pain in both the area of contraction and in other locations. Orbicularis-oris activity, when pressing lips together, also evokes activation in other peri-oral muscles (i.e. depressor anguli oris, depressor labii, and mentalis) [41]. Orbicularis-oculi activity, the performance of blink detection is better at the superomedial quadrant than at the inferolateral quadrant [42]. It seems that the superomedial quadrant activity is associated with movements of both frontalis and temporalis muscles. Thus, it is suggested that orbicularis-oculi contractions can induce headaches, whereas orbicularis-oris contractions may not tend to cause the symptoms at the superomedial quadrant. In this study, some participants developed head pain by the experimental contractions (jaw-closing and orbicularis-oculi muscle groups), but this was not consistent. There is also a report that headache patients are likely to report oral parafunctional behaviors more often than non-headache controls [26]. Thus, craniofacial muscle activity is considered one factor that may cause headache, and there may be a tendency that temporalis muscle activity can cause more headache than other facial muscles.

In conclusion, this study suggests that (1) the jaw-closing muscles might be more resistant to fatigue than other muscles, e.g. limb muscles, and (2) the development of muscle symptoms in jaw-closing muscles might differ from the O-oris and O-oculi. Further studies are warranted to better understand the contribution of specific craniofacial muscle groups for the characteristic presentation of various craniofacial pain conditions such as in myofascial temporomandibular disorder and tension-type headache.

Acknowledgments

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Figure Legends

Table 1 The mean of maximal voluntary contraction force (MVCF) in the jaw-closing (Jaw), the orbicularis oris (O-oris), and the orbicularis oculi (O-oculi) sessions. MVCF were measured at baseline and immediately after the experimental contractions (Period 6).

Table 2 The numbers with * are words used by at least 30% of the 16 participants to describe their pain. Jaw = jaw-closing muscles, O-oris = orbicularis oris, O-oculi = orbicularis oculi. At baseline in all sessions and at 24 h and 48 h follow up in the O-oris and the O-oculi clenching sessions, none of the participants reported any pain.

Table 3 At baseline in all sessions and at 24 h and 48 h follow up of the orbicularis oris (O-oris) and the orbicularis oculi (O-oculi) clenching sessions, none of the participants reported any pain. * Significantly different from control.

Table 4 Subjective descriptions of the pain extent on an anatomical drawing from a lateral, intraoral, and frontal perspective. There were no pain reports at baseline in any of the sessions and at 24 h and 48 h follow up of the orbicularis oris (O-oris) and the orbicularis oculi (O-oculi) clenching sessions. (n = 16). * Significantly different from control.

Fig. 1 Experimental design. Black boxes = Six bouts of five minutes contraction task at 20% maximal voluntary contraction force (MVCF); NRS = Numeric Rating Scales; MPQ = McGill Pain Questionnaire; PRI = Pain Rating Index; and DRAW = Drawing of perceived pain area.

Fig. 2 (a1) A force transducer for the Jaw contraction task (a2). The participants held the force transducer between the first molars on the right side (b1). A force transducer for the O-oris task (b2). The participants held the force transducer coated with a customized silicone impression template between the upper and lower lips (c1). A force transducer for the O-oculi task. (c2) the participants held the silicone coated force transducer that was customized individually to fit the right side eye orbit prior to the experimental session.

Fig. 3 Mean (± SD) values of the subject-based scores on Numeric Rating Scales (NRS) (pain, unpleasantness, fatigue, and stress) from the three experimental contraction sessions (jaw-closing (Jaw), orbicularis oris (O-oris), and orbicularis oculi (O-oculi)). * = $P < .050$ significantly different from control; ¬ = $P < .050$ significant difference between sessions; Period 6 = immediately after the last contraction task1 h = one hour, 24 h = 24 hours, and 48 h = 24 hours after the last experimental contraction in a session.

Fig. 4 Illustrations of patient-based drawings of spatial extent of perceived pain from three contraction sessions (jaw-closing (Jaw), orbicularis oris (O-oris), and orbicularis oculi (O-oculi)). * at the upper left of the drawing = $P < .050$ significantly different from control; Period 6 = immediately after the last contraction task; 1 h = one hour, 24 h = 24 hours, and 48 h = 48 hours after the last experimental contraction in a session.

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Fig. 1 Experimental design.

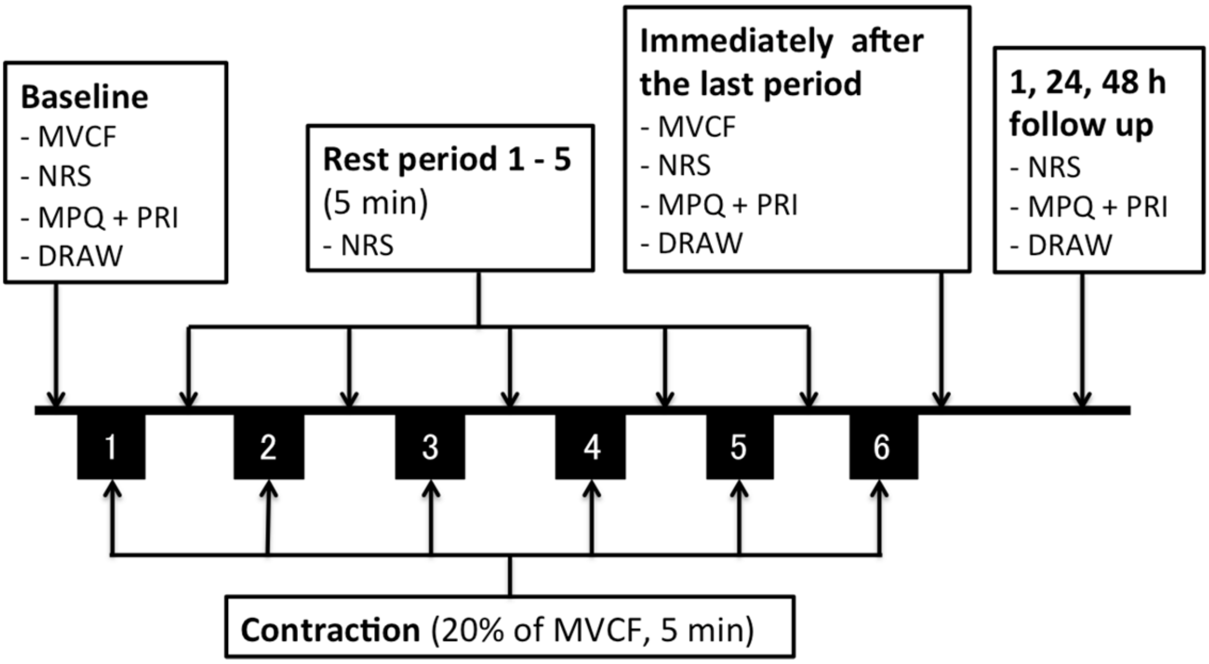

Fig. 2 The force transducer

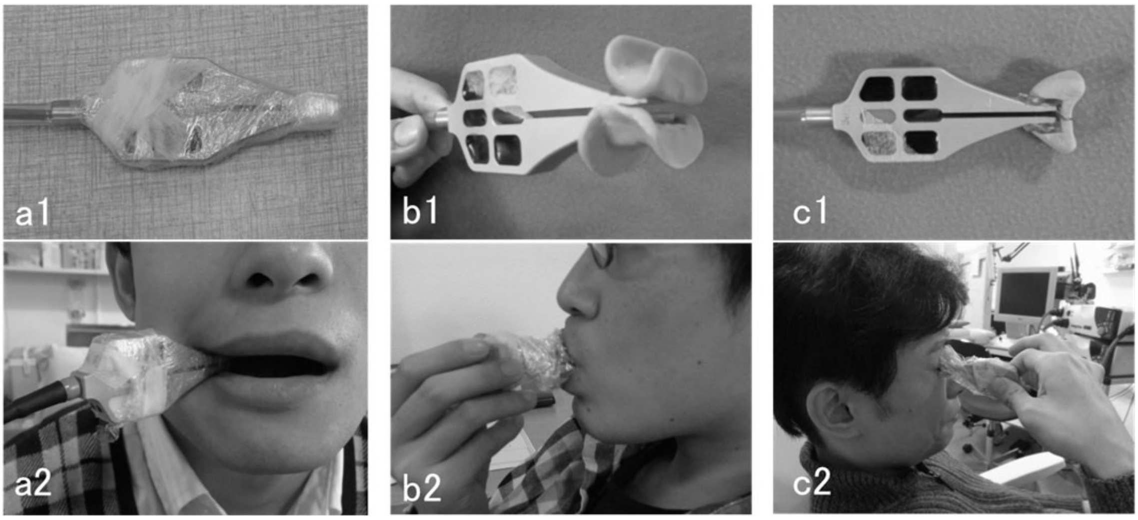

Fig. 3 Mean values of the subject-based scores on Numeric Rating Scales (NRS) (pain, unpleasantness, fatigue, and stress) from the three experimental contraction sessions.

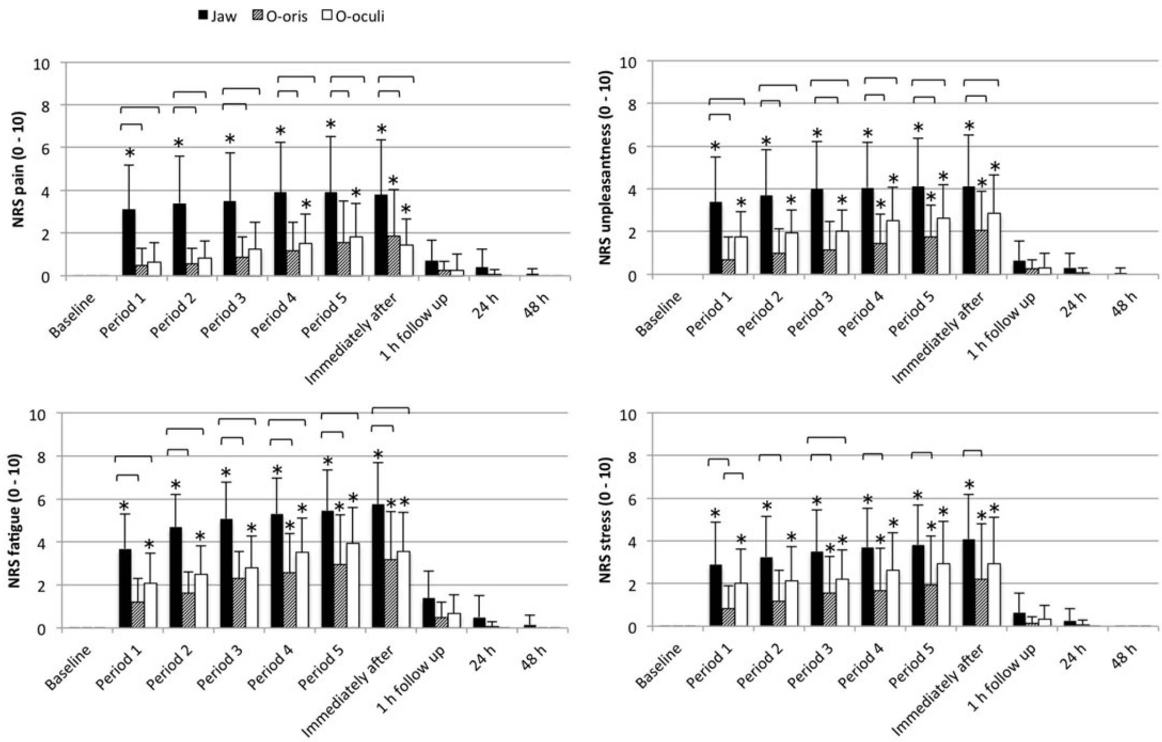

Fig. 4 Illustrations of the patient-based drawings of the spatial extent of the perceived pain from the three contraction sessions.

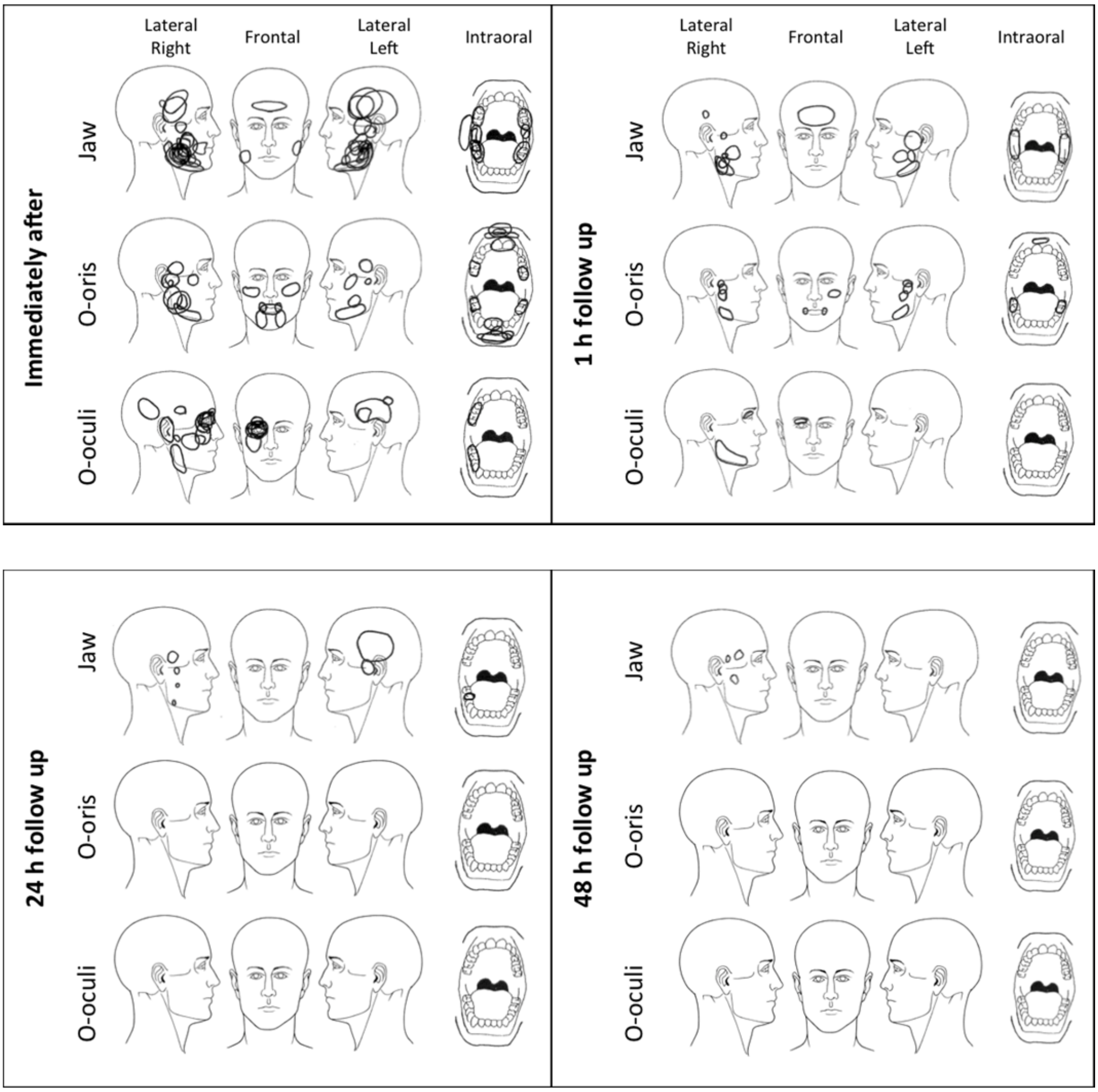

Table 1 Maximal Voluntary Contraction Force (MVCF) of three muscles at baseline and after the contraction tasks.

MVCF (Mean ± SD) (N)		
	Baseline	Immediately after
Jaw	305.6 ± 134.5	313.4 ± 157.5
O-oris	6.7 ± 1.8	6.5 ± 2.3
O-oculi	1.1 ± 0.4	1.3 ± 0.7

Table 2 The most frequently used words on the McGill Pain Questionnaire (MPQ)

The Most frequently Used Words on the MPQ (numbers / %)								
	Jaw				O-oris		O-oculi	
Words	Immediately after	1 h	24 h	48 h	Immediately after	1 h	Immediately after	1 h
QUIVERING	5 / 31.3 *	1 / 6.3	0 / 0.0	0 / 0.0	2 / 12.5	1 / 6.3	3 / 18.8	1 / 6.3
PRESSING	4 / 25.0	5 / 31.3*	0 / 0.0	0 / 0.0	3 / 18.8	0 / 0.0	6 / 37.5*	0 / 0.0
DULL	5 / 31.3*	2 / 12.5	1 / 6.3	1 / 6.3	1 / 6.3	1 / 6.3	3 / 18.8	0 / 0.0
ANNOYING	1 / 6.3	0 / 0.0	0 / 0.0	0 / 0.0	1 / 6.3	0 / 0.0	5 / 31.3*	0 / 0.0

Table 3 Pain Rating Score (PRI) after the experimental contraction sessions.

PRI after the experimental contraction (Mean ± SD)	Jaw				O-oris		O-oculi	
	Immediately after	1 h	24 h	48 h	Immediately after	1 h	Immediately after	1 h
Sensory	6.6 ± 6.8	2.4 ± 4.2	0.3 ± 0.8	0.1 ± 0.2	4.2 ± 5.3	0.4 ± 0.9	3.5 ± 5.0	0.3 ± 0.8
Affective	1.2 ± 2.1	0.4 ± 1.1	0.1 ± 0.5	0.0 ± 0.0	0.4 ± 1.5	0.1 ± 0.2	0.4 ± 1.0	0.0 ± 0.0
Evaluative	1.3 ± 1.7	0.3 ± 0.7	0.1 ± 0.5	0.0 ± 0.0	0.4 ± 0.8	0.0 ± 0.0	0.6 ± 1.2	0.0 ± 0.0
Miscellaneous	2.1 ± 3.4	0.3 ± 0.8	0.0 ± 0.0	0.1 ± 0.5	0.7 ± 1.5	0.0 ± 0.0	1.0 ± 1.7	0.3 ± 1.0
Total Score	11.1 ± 12.3*	3.4 ± 6.5	0.6 ± 1.7	0.2 ± 0.7	5.8 ± 8.3	0.4 ± 0.9	5.6 ± 7.0*	0.6 ± 1.7

Table 4 Drawing of Perceived Pain Area

Area of Pain Drawing (Mean ± IQR) (mm²)									
	Jaw			O-oris			O-oculi		
	Lateral	Intraoral	Frontal	Lateral	Intraoral	Frontal	Lateral	Intraoral	Frontal
Immediately after	91.9 ± 103.5*	26.8 ± 9.1	4.2 ± 0.0	22.4 ± 42.7	22.4 ± 16.4	9.5 ± 4.3*	34.3 ± 45.5	6.0 ± 0.0	13.0 ± 14.7
1 h	13.4 ± 14.4	5.1 ± 0.0	5.8 ± 0.0	5.9 ± 0.0	0.7 ± 0.0	1.1 ± 0.0	4.9 ± 0.0	0.0 ± 0.0	0.6 ± 0.0
24 h	12.2 ± 0.0	0.3 ± 0.0	0.0 ± 0.0	5.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
48 h	0.8 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0