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Co-activation of jaw and neck muscles during submaximum clenching in the supine position

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ABSTRACT

Objective: The purpose of this study was to test the hypothesis that jaw clenching induces co-contraction and low-level long-lasting tonic activation (LLTA) of neck muscles in the supine position.
Design: Ten healthy subjects developed various feedback-controlled submaximum bite forces in different bite-force directions in supine position. The electromyographic (EMG) activity of the semispinalis capitis, semispinalis cervicis, multifidi, splenius capitis, levator scapulae, trapezius, sternocleidomastoideus, masseter and infra/supra-hyoidal muscles was recorded. For normalization of EMG data, maximum-effort tasks of the neck muscles were performed.
Results: Co-contractions of the posterior neck muscles varied between 2% and 11% of their maximum voluntary contraction. Different bite forces and bite-force directions resulted in significant ($p < .05$) activity differences between the co-contraction levels of the neck muscles. In addition, LLTA of specific neck muscles, provoked by the jaw clenching tasks, was observed.
Conclusions: This study demonstrated for the first time moderate co-contractions of jaw and neck muscles in the supine position under controlled submaximum jaw clenching forces. LLTA of most neck muscles was observed, outlasting clenching episodes and indicating an additional neuromuscular interaction between the two muscle groups.

1. Introduction

Neck pain is a common musculoskeletal disorder with substantial overlap of signs and symptoms in patients with temporomandibular and cervical spine disorders (TMDs and CSDs, respectively).[1] The comorbidity of TMDs and CSDs has been reported in numerous studies[2–4] and the substantial prevalence of TMDs in CSD patients,[5] and vice versa,[6–8] suggests a pathophysiological interaction between the masticatory and the cervical muscles. Considering the multifactorial aetiology of masticatory muscle pain and neck pain it is speculated that overloading by jaw clenching and/or grinding of the teeth (bruxism) might be a risk factor for myofascial neck pain.[9–11]

On the basis of clinical findings,[12] however, distinction between daytime and sleep bruxism is necessary, because the biomechanical conditions of the neck differ substantially in

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the upright and the supine body positions. Sleep bruxism involves the development of rhythmic masticatory muscle activity which can be divided into three categories: phasic (grinding), tonic (clenching), and mixed.[13,14] Pure clenching occurs in approximately 10% of bruxers, but it is also part of the mixed type, which can be observed in approximately 35% of the target population.[13] Masticatory muscle activity levels at clenching during sleep bruxism fall within a submaximum range of biting with an upper limit of approximately 50% of the maximum voluntary clenching (MVC).[15,16]

Recent electromyographic (EMG) studies have shown that superficial and deep neck muscles co-contract during a variety of force-controlled submaximum biting tasks in an upright seated body position.[17,18] Surprisingly, for several neck muscles low-level long-lasting tonic activation (LLTA), outlasting the specific submaximum motor tasks, have also been detected.[17,18]

Previous experiments have revealed co-activation of masticatory and single neck muscles during maximum bite forces in seated and lying subjects.[10,11,19–22] There is, however, no evidence of co-contractions between the masticatory system and the superficial and deep neck muscles under force-controlled bruxing conditions which load the masticatory muscles in the submaximum range of voluntary clenching in the supine position.

The primary objective of this study was to test the hypotheses that jaw muscles and neck muscles from superficial and deep layers co-contract during force-controlled submaximum biting tasks performed in a supine position, and that LLTA of the neck muscles can be induced by clenching in the supine body position, as has been observed in the sitting position. The experiments might elucidate possible neuromuscular interactions comparable to those taking place during sleep bruxism. A secondary objective, related to the normalization procedure for the EMG data, was to determine the maximum forces and EMG activity which neck muscles can develop in different horizontal directions transmitted at the forehead level.

2. Materials and methods

2.1. *Subjects*

Ten symptom-free graduate dental students (three female, seven male; average age 24 ± 2.3 years), assessed by means of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD),[23] were enrolled in the experiment. Exclusion criteria were clinically obvious skeletal anomalies (e.g., short-faced or long-faced) and malocclusions (e.g. Angle class II and III), parafunctional habits, operations, injuries, painful dysfunction of the cranial or cervical region or any treatment needed in these regions (detected by asking the subjects by means of a questionnaire). The study was approved by the Ethics Committee of the University Medical Centre, Heidelberg (no. S-213/2008). All participating subjects gave their informed written consent to the experiments. The experimental procedures were conducted in accordance with the Helsinki Declaration of 1964, as revised in 2008.

2.2. *Intraoral force simulation and force measurement*

Bite force was transmitted by an intraoral ''bearing pin device'' equipped with strain gauges (3/120 LY 11; Hottinger Baldwin Messtechnik, Darmstadt, Germany) and mounted on a metal splint.[24] The base plate of the bearing pin and the contact plate of the mandible were attached parallel to the occlusal plane of the lower jaw. On the contact plate the pin met the point of intersection of a connecting line between the lower first molars and the midsagittal plane. A perforation in the contact plate with a loose fit for the tip of the pin enabled joint connection at the force transmission point (central jaw position). Jaw separation at the incisors was adjusted to 5 mm. The transducer measured forces in three orthogonal directions relative to the occlusal plane[17] as described below in detail. The signals were amplified by use of a measuring amplifier (MGCplus ML55B; Hottinger Baldwin Messtechnik, Darmstadt, Germany) and displayed on a monitor. The signals were digitized (sampling rate 1500 Hz) and recorded simultaneously with the electromyographic (EMG) signals.

2.3. *Feedback*

A feedback monitor was mounted on a specially designed frame which enabled the test persons to watch it when in the supine position on a massage couch. The intraorally measured force vector was displayed to the subjects on the monitor,[25] on which target values were also indicated. The angle φ (angle between the x-axis and the projection of the force vector on to the x–y plane) and the angle θ (angle between the z-axis and the force vector) of the spatial force vector generated by the subjects were displayed in a planar coordinate system as a vector. The angles φ and θ were plotted in the circumferential and radial directions, respectively. A pure vertical force corresponded, therefore, to $\theta = 0^\circ$, and a pure horizontal force to $\theta = 90^\circ$. The magnitude of the force was shown on the display as an additional vertical bar with a scale.

2.4. *Measurement of the strength of the neck muscles*

A special measurement device was developed to record EMG data during maximum-effort tasks of the neck muscles, as described in previous studies.[18] Recording of maximum electrical muscle activity is a prerequisite for normalization of submaximum EMG activity measured during force-controlled motor tasks.[26] Maximum strength and the corresponding maximum EMG activity are usually developed in the loading direction with the optimum biomechanical advantage for the individual muscle. The device consisted of eight vertical rods in a circular arrangement, separated by 45° angles, concentrically connected by horizontal bars to a bending beam in the middle of the apparatus. The beam was equipped with four strain gauges (6/120 LY 11; Hottinger Baldwin Messtechnik, Darmstadt, Germany) for two-dimensional force measurement. During the experiments the test person sat on a chair with the upper part of the body fixed to the back of the chair by means of a Velcro band. The force-measurement apparatus, which was connected to the chair, could be adapted to the individual anatomical geometry of the subject such that all vertical rods were in gentle contact with