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Differential patterns of muscle modification in women with episodic and chronic tension-type headache revealed using surface electromyographic analysis

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ABSTRACT

Tension-type headache (TTH) is a prototypical disorder in which muscular factors play a key role in the pathogenesis. This study was designed to understand muscular dysfunction in patients with episodic (ETTH) and chronic TTH (CTTH) using surface electromyography analysis (SEMG). Women with frequent ETTH ($n = 14$), CTTH ($n = 14$) and age-matched controls ($n = 13$) were recruited. SEMG data were recorded from the masseter, sternocleidomastoid, and upper trapezius muscles during maximum voluntary contraction and sustained voluntary isometric clenching, the neck flexion endurance test and shoulder elevation for 30 s. The root mean square (RMS) and median frequency (MDF) of the SEMG signal were measured throughout the test. The fatigue index, which is the MDF slope during sustained muscle contraction, decreased significantly faster in the ETTH and CTTH groups compared with that in the control ($p < 0.05$). The mean absolute RMS and relative percentage values at the initial and final period during sustained isometric contraction decreased significantly in the CTTH group ($p < 0.05$). Furthermore, headache clinical parameters (frequency and duration) were negatively correlated with the amplitude values ($p < 0.05$). A different muscle firing pattern or some muscle modifications in patients with CTTH may reflect reorganization of the motor-control strategy.

1. Introduction

Tension-type headache (TTH) is the most common and prevalent of the headaches [Headache Classification Subcommittee of the International Headache Society, 2004]. The lifetime prevalence of migraine and TTH are 8% and 69% in men and 22% and 88% in women, respectively. Women have a higher prevalence than men of headache, migraine, and TTH [Rasmussen et al., 1991]. TTH is classified into two categories: episodic (ETTH) and chronic (CTTH) [Headache Classification Subcommittee of the International Headache Society, 2004]. Although the majority of TTH patients have no more than one headache per month, as many as 18–37% experience several headaches per month, whereas 2–3% suffer from CTTH [Rasmussen et al., 1991]. CTTH differs from ETTH not only in frequency but also with respect to pathophysiology. CTTH lacks effective treatment strategies, resulting in greater medication overuse, greater disability, and higher personal and socioeconomic costs [Bendtsen and Jensen, 2006]. Despite the high prevalence and overall cumulative socioeconomic impact of the condition, our understanding of TTH pathophysiology is still in the early stage.

TTH is a prototypical disorder in which neck and shoulder muscles may play an important etiological role. Muscular factors of the pericranial and neck–shoulder region seem to be important in all patients with ETTH and CTTH. Peripheral activation or sensitization of myofascial nociceptors may cause increased pain sensitivity and decreased pain threshold in patient with TTH [Bendtsen and Fernandez-de-la-Penas, 2011]. Sensitization of pain pathways in the central nervous system (CNS) due to prolonged nociceptive input from muscles may play an important role in the conversion of ETTH to CTTH. The CNS is sensitized in patients with CTTH, whereas central pain processing seems to be normal in patients with ETTH [Bendtsen and Jensen, 2006]. The origin of pain in patients with TTH has been attributed to increased contraction of head and neck muscles. Therefore, many researchers have used electromyography (EMG) to explore the possibility of a relationship between pericranial muscle activity and headache.

Many laboratory-based EMG studies have reported normal or only slightly increased muscle activity during TTH. Several studies have demonstrated an increase in EMG activity, indicating insufficient muscle relaxation during TTH [Clark et al., 1995; Jensen et al.,

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1994; Pritchard, 1995]. However, experimental data do not show any relationship between EMG and headache status, suggesting that muscle activity plays no causal role and is possibly a secondary protective mechanism [Bansevicius et al., 1997, 1999; Jensen and Olesen, 1996]. Each of these studies primarily evaluated baseline EMG activity and suggested that the increased EMG activity in patients with TTH might be an epiphenomenon rather than a primary cause of pain.

Recent studies have investigated the dynamic behavior of the pericranial and neck muscles in patients with TTH. Patients with CTTH exerted lower maximal force and showed greater coactivation of antagonist muscles during cervical extension/flexion contractions than did healthy controls [Fernandez-de-las-Penas et al., 2008]. Another study reported that girls with TTH and migraine showed differences in neuromuscular function in the neck and shoulder muscles. Girls with TTH displayed lower shoulder flexion force and a decreased EMG/force ratio, whereas girls with migraine had a higher EMG/force ratio between agonist muscles and the corresponding maximal neck flexion/rotation force [Oksanen et al., 2008]. Other studies have reported increased pericranial muscle fatigue in patients with CTTH and fatigue of the neck flexor muscles in adolescent patients with TTH [Jensen et al., 1994; Oksanen et al., 2007]. These dynamic assessments of EMG changes induced by different experimental conditions have increased our knowledge of muscular changes as a consequence of headache and of the possible role of muscular function in headache etiology.

We hypothesize that there are differences in muscular changes between ETTH and CTTH because of pain characteristics such as pain frequency. Therefore, we investigated whether pericranial–neck–shoulder muscular changes are a cause or an effect of headache by examining fatigue patterns and muscle activity during sustained isometric contraction using surface electromyography (SEMG) analysis in patients with ETTH and CTTH .

2. Methods

2.1. Subjects

Female patients between 20 and 70 years of age with TTH who had visited the headache clinic of a tertiary care hospital were recruited for this study. Headache diagnoses were made by a board-certified attending neurologist using International Headache Society (IHS) criteria. Patients with ETTH were defined as those with headaches 1–15 days per month (frequent ETTH). Because infrequent ETTH is considered a normal phenomenon and not a disease, patients with infrequent ETTH were not included in the ETTH group. Patients with CTTH were those who had headaches at least 15 days per month for more than three successive months. For inclusion in the TTH group, subjects had at least a 1-year history of headache and typical symptoms of TTH to distinguish these from mixed headaches (i.e., coexistence of TTH and migraine). Patients who were administered analgesics or muscle relaxants within 24 h prior to the investigation or who overused medications for headache as defined by the IHS were excluded. The control group consisted of age-matched volunteers recruited from among the relatives or friends of patients. Participants in the control group were free of headache for at least 3 months prior to the study and experienced no more than occasional mild headaches (<5 times per year), for which they had never sought medical treatment. Exclusion criteria were the presence of pain in the musculoskeletal and dental system; history of neck, temporomandibular joint, shoulder, or back surgery; and the presence of neurological deficits or a rheumatoid disorder. The patients and the control group included only women to avoid sex-biased effects. The influence of gender may have a significant impact on various EMG indices [Albert et al., 2006; Pincivero et al., 2000]. All subjects were right handed and were examined when free of headache. None of the subjects reported subjective neck–shoulder symptoms on the examination day. No patient had to be excluded because of headache attacks or neck–shoulder symptoms during the test. All subjects gave written informed consent to participate in the study, and this study was approved by the local ethics committee.

2.2. Headache characteristics

All participants were examined physically and neurologically by an experienced neurologist. Computed tomography or magnetic resonance imaging of the brain and cervical spine X-rays were performed in all patients with headache. These radiological examinations indicated no pathological findings in any subject. The participants were asked to complete a questionnaire regarding their headache symptoms, including frequency, duration, and intensity of headache during the previous 4 weeks. Headache frequency (days/week) was calculated by dividing the number of days with headache by 4 weeks. Headache duration (day) was calculated by dividing the sum of the total hours of headache by the number of days with headache, and headache intensity (numeric rating scale [NRS]: 0–10) was calculated from the mean NRS for the days with headaches. Additionally, all subjects were evaluated for pericranial–neck–shoulder muscle tenderness by manual palpation. One rehabilitation physician, who was blinded to patient information and diagnosis, identified myofascial trigger points (MTrP) in the bilateral masseter (MAS), sternocleidomastoid (SCM), and upper trapezius (UT) muscles in all subjects. We used the methods of Gerwin et al. to identify MTrPs [Gerwin et al., 1997]. The number of MTrPs on each muscle was recorded.

2.3. Test protocols

The EMG examination was standardized and performed by one rehabilitation physician who was blinded to patient history. The procedure was explained to the subjects before the test started. For the MAS contraction test, subjects were instructed to bite maximally with their molar and premolar teeth (jaw clenching) while wearing a mouthpiece. Before the test, we immersed the mouthpiece in hot water to make it pliable and placed it on the upper jaw. We confirmed that the mouthpiece covered the molar area. Using this method, we adapted the mouthpiece to the individual dental characteristics of each subject.

We performed the neck flexion test described by Janda as the SCM contraction test [Janda, 1983; Oksanen et al., 2007]. The subjects reclined on a plinth in a sagittally symmetrical supine position. Both shoulders and the thorax were against a plinth. The knees were at a 60° angle and supported with a roll pad under the knees, with both upper extremities straight at the sides. The subject was asked to jut out their chin as far as possible. The chin position was controlled by a small ball hanging from the ceiling. The subject sat on a chair for selective and isometric UT contraction, with arms straight alongside the body to reduce involvement of the biceps and deltoid muscles. The subject's back was leaned against the back of the chair to avoid erector spinae muscle activity, and the feet were raised to avoid contribution from lower-limb muscles. The height of the UT was carefully aligned with the rotational axis of a Contrex isokinetic dynamometer (CMV AG, Dubendorf, Switzerland), and the subject's right or left UT muscles touched the lever arm pad of the dynamometer. The dynamometer was set to isometric mode, and the subjects were asked to shrug their shoulders against the pad of the dynamometer lever arm. The order of isometric right and left shoulder shrugging was randomized. A mini trial was performed to familiarize the subjects with the experimental procedure. After warm-up, each subject per-