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The Effect of Experimental Neck Pain on Pressure Pain Sensitivity and Axioscapular Motor Control

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Abstract: **Clinical neck pain affects pain sensitivity and coordination of neck muscles, but the impact on the shoulder muscles is unclear. This study investigated the effect of experimental neck pain on the activity of the axioscapular muscles during arm movements and changes in pain sensitivity. Experimental neck pain was induced in 24 healthy volunteers by injecting hypertonic saline into the splenius capitis. Isotonic saline was injected as control. Before, during, and after injections, electromyography was recorded bilaterally from 8 muscles during standardized arm movements (140° scapular plane elevation), and the root mean square amplitude was extracted. Likewise, pressure pain thresholds were assessed bilaterally on 3 sites. The root mean square electromyography was decreased for the ipsilateral upper trapezius ($P < .01$) and increased for the ipsilateral middle deltoid ($P < .03$) during upward movements. The root mean square electromyography was reduced for the ipsilateral upper trapezius ($P < .01$) during downward movement, whereas an increase was recorded in the contralateral external oblique ($P < .02$). At the injection site, the pressure pain threshold increased during pain compared with the post condition (5 minutes after potential pain had subsided; $P < .03$). In this study, trunk and axioscapular muscle activities were reorganized in response to localized and referred pain evoked by hypertonic saline injection into an intrinsic neck muscle with no direct attachments to the trunk or shoulder girdle.**

Perspective: ***Reorganized activity of the axioscapular muscles has been shown previously in neck pain patients and is believed to happen during the transition from acute to chronic pain. The present study demonstrates for the first time that such reorganization may happen acutely, adding to our understanding of the effects of acute neck pain.***

Key words: *Neck, shoulder, pain, experimental, axioscapular.*

Neck pain is a frequent problem in the general population,[29,34] affecting up to 54% of adults during a 6-month period[15] (many of whom will develop prolonged or recurrent symptoms), making this a serious problem and a burden to the health care system.[4,15,46]

Several studies on neck pain have proposed a link between neck pain and changed motor control of cervical muscles, that is, deep neck flexors and extensors and the sternocleidomastoid.[5,8,14,33,45] Moreover, inclusion of the shoulder girdle as part of both assessment and targeted neck pain management has been suggested.[6,32,34,44,58] This is based on clinical observations of abnormal axioscapular function during upper limb tasks in neck pain patients[34,44] and studies showing abnormal shoulder girdle alignment, with neck pain patients displaying protracted shoulders and less scapular upward rotation than healthy controls.[20,55] Helgadottir et al[19] found reduced activity of the serratus anterior but no changes in the trapezius in neck pain patients during abduction in the scapular plane (scaption). This is in contrast to Falla et al,[10] who reported reduced activity in the upper trapezius in neck pain patients during arm movement. Recently, Zakharova-Luneva et al[58] could not demonstrate reduced activity in the upper or middle part of the trapezius but found increased activity of the lower part in neck pain patients. These varied findings of different studies could be attributed to the different tasks and movement speeds investigated. Previous studies assessing muscle

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activation patterns during arm movements have found these to be related to movement speed, showing faster muscle onset and increased activity during fast movements compared to slow.[28,37] In addition, studies have shown that both clinical and experimental pain can affect muscle onsets as well as activity levels,[13,19,26,50] and some changes were visible for only fast but not slow movements.[25] So far, changes in axioscapular muscle activity during scaption (arm movements in the scapular plane) have been found in patients who have suffered from neck pain for at least 3 months, so it is unknown if acute neck pain causes these changes or if a change in axioscapular muscle activity is a predisposing factor for neck pain. Because of logistical problems recruiting neck pain patients immediately after the initial pain onset, a model utilizing experimental pain might be optimal for investigating the effect of acute neck pain and may indicate relevant changes during the initial stage of clinical neck pain.

Along with changes in motor control, localized hyperalgesia to pressure is generally found in neck pain patients when compared with healthy controls.[35,36,49,52-54] Interestingly, chronic but not acute idiopathic neck pain patients demonstrated widespread changes with hyperalgesia at the anterior tibial muscle when compared with healthy controls.[30] This is in agreement with recent suggestions that a prolonged localized nociception may drive sensitization of central mechanisms, causing spreading sensitization.[18] This is in contrast to experimental studies with injection of hypertonic saline into a neck muscle[17,48] that found no local changes but instead found evidence of hypoalgesia in the surrounding tissue.[17] It is still to be investigated if experimentally induced neck pain causes widespread changes.

The purpose of this study was to investigate if experimentally induced neck pain affects motor control of axioscapular muscles during arm movements (scaption) and increases the pain sensitivity when compared to a nonpainful control condition. It was hypothesized that experimental neck pain reorganizes coordination of the axioscapular muscles during slow and fast arm movements. Muscle onsets were expected to be affected during fast movements in a painful condition. Further, segmental hypoalgesia was expected as a result of experimental pain. No gender effects were expected.

Methods

Subjects

Twenty-five healthy volunteers (13 women) were included. Female participants had a mean age of 25.9 years (standard deviation [SD] = 3.8) and body mass index equal to 22.7 (SD = 2.3), whereas male participants had a mean age of 28 years (SD = 5.4) and a body mass index equal to 23.7 (SD = 3.8). Analysis of demographic data revealed no significant difference of age and body mass index between genders. One participant was left handed. Exclusion criteria were any history of neck or shoulder pain within the past 6 months, signs or symptoms indicating neurologic or rheumatologic disorders that could influence the results, current use of pain medication, or pregnancy. All subjects had normal pain-free ranges of motion of the neck and shoulder.[43] Subjects gave informed consent after having received written and verbal information on the study protocol. The study was conducted in accordance with the Helsinki declaration and was approved by the local ethics committee (N20120018).

Protocol

The study used a single-blinded, randomized, crossover design (Fig 1). Subjects were seated in an upright position for muscle activity measurements during scaption or leaning over a bench for pressure algometry assessments. Pressure algometry and electromyography (EMG) were assessed bilaterally, and the order of which measurement was recorded first was randomized in a balanced design. Experimental pain was induced by injecting hypertonic saline into a neck muscle. The side selected for the experimental pain was randomized in a balanced way between the right and left sides. A control injection of isotonic saline was used on the contralateral side. Participants were blinded to which injection they would receive, and the sequence of injections (hypertonic first or isotonic first) was randomized although balanced. The measurements were recorded at baseline, immediately after the injection, and 5 minutes after the potential pain had subsided. Thus, the time between the last 2 recordings was different between the isotonic and hypertonic saline recordings. "Post" recording was conducted 5 minutes after the potential pain had vanished. After the first post recording, there was a gap of 5 minutes before the next baseline were recorded. Data collection was completed in 1 session.

Experimental Neck Muscle Pain

Experimental muscle pain was induced in the splenius capitis by injection of sterile hypertonic saline (.5 mL,

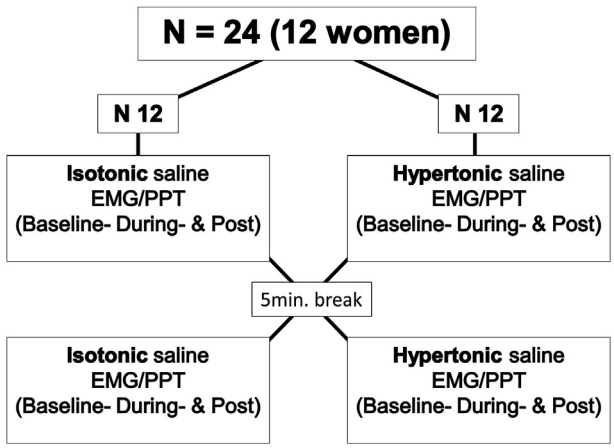

Figure 1. Single-blinded randomized crossover design. Order of saline type or PPT/EMG data collected first was randomized in a balanced way. The measurements were recorded at baseline, immediately after the injection (During), and 5 minutes after the potential pain had subsided (Post).