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Latent Myofascial Trigger Points Are Associated With an Increased Intramuscular Electromyographic Activity During Synergistic Muscle Activation

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Abstract: **The aim of this study was to evaluate intramuscular muscle activity from a latent myofascial trigger point (MTP) in a synergistic muscle during isometric muscle contraction. Intramuscular activity was recorded with an intramuscular electromyographic (EMG) needle inserted into a latent MTP or a non-MTP in the upper trapezius at rest and during isometric shoulder abduction at 90° performed at 25% of maximum voluntary contraction in 15 healthy subjects. Surface EMG activities were recorded from the middle deltoid muscle and the upper, middle, and lower parts of the trapezius muscle. Maximal pain intensity and referred pain induced by EMG needle insertion and maximal pain intensity during contraction were recorded on a visual analog scale. The results showed that higher visual analog scale scores were observed following needle insertion and during muscle contraction for latent MTPs than non-MTPs ($P < .01$). The intramuscular EMG activity in the upper trapezius muscle was significantly higher at rest and during shoulder abduction at latent MTPs compared with non-MTPs ($P < .001$). This study provides evidence that latent MTPs are associated with increased intramuscular, but not surface, EMG amplitude of synergist activation. The increased amplitude of synergistic muscle activation may result in incoherent muscle activation pattern of synergists inducing spatial development of new MTPs and the progress to active MTPs.**

Perspective: ***This article presents evidence of increased intramuscular, but not surface, muscle activity of latent MTPs during synergistic muscle activation. This incoherent muscle activation pattern may overload muscle fibers in synergists during muscle contraction and may contribute to spatial pain propagation.***

Key words: *Intramuscular electromyography, isometric contraction, motor control, muscle synergy, myofascial trigger points.*

A latent myofascial trigger point (MTP) is defined as a focus of hyperirritability in a muscle taut band that is clinically associated with local twitch response and tenderness and/or referred pain upon manual examination.[8,11,21] Local tenderness and/or referred pain from a latent MTP are transient in duration upon mechanical stimulation, and a latent MTP exists without spontaneous pain.[8] Latent MTPs may not only become active MTPs, which contribute significantly to the pain profiles in myofascial pain conditions, but also induce motor dysfunctions, predisposing the muscle to further damage.[21] Recent experimental evidence has shown that the existence of latent MTPs contributes to the impaired muscle recruitment or activation timing when performing active joint movement,[16] to the restricted joint range of motion in the ankle[13] and in the neck,[1,19] and to an accelerated development of muscle fatigue with simultaneous overloading of the active motor units close to a latent MTP.[9] Moreover, latent MTPs may also contribute to the delayed and incomplete muscle relaxation, distorted fine movement control, and unbalanced muscle activation when performing joint movement involving an agonist and antagonist muscle pair.[14] To achieve optimal joint movement, a group of

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muscles have to work synergistically for certain motions. An example of muscle synergies can be observed during abduction of the arm, as the upper trapezius is synergistic with glenohumeral movement by the deltoid and supraspinatus muscles.[25] However, the effects of MTPs on the motor control between synergistic muscles are still unknown. Clinically, it is quite often that neck pain and shoulder pain coexist in chronic musculoskeletal pain conditions. Further understanding of the intramuscular activity from a latent MTP during joint movement involving a synergistic muscle group may provide evidence for the effects of MTPs on the motor control between synergistic muscles.

The aim of the study is to quantify intramuscular and surface electromyographic (EMG) activities from a latent MTP as compared to a non-MTP in the upper trapezius as a synergistic muscle during shoulder abduction in healthy humans.

Methods

Subjects

Fifteen healthy subjects (8 males and 7 females: mean age, 25 $\pm$ .8 years; mean weight, 66 $\pm$ 2.1 kg; mean height, 171 $\pm$ 1.5 cm), with no signs or symptoms of musculoskeletal pain, volunteered for this study. This study was approved by the local ethics committee (N-20100048) and conducted in accordance with the Helsinki Declaration. Informed consent was obtained prior to experiment.

Experimental Protocol

This experiment consisted of 2 sessions in which an intramuscular EMG needle electrode was inserted into either a latent MTP or a non-MTP in the upper trapezius muscle on the dominant side. There was a 1-day interval between 2 sessions. The intramuscular EMG needle insertion into the latent MTP or a non-MTP was randomized. Intramuscular EMG activities from the upper trapezius muscle and surface EMG activities from the middle deltoid muscle and upper, middle, and lower trapezius muscles were simultaneously recorded at rest and during 25% of maximal voluntary contraction (MVC) force of shoulder abduction at 90°. Local pain intensity was recorded on visual analog scale (VAS) immediately following EMG needle insertion and following isometric muscle contractions (detailed later). Referred pain pattern from needle insertion was recorded on an anatomic map at the end of each session.

Each subject was seated in a chair with back support. The subject was asked to relax the dominant arm on supporting plate to form a 90° of passive shoulder abduction. A force transducer (MC3 A; AMTI, Watertown, MA) was in close contact with the upper surface of the upper arm just above the elbow level. Following MVC determination, with the needle at a latent MTP or a non-MTP in the muscle, each subject was asked to gradually increase the contraction force to reach the target force level of 25% of the MVC within 2 seconds and then to keep at the target force level for 7 seconds. The target force was displayed on the monitor screen as the visual feedback.

Active shoulder abduction was achieved by the isometric contraction of the middle deltoid muscle (prime mover) against the force transducer. The upper trapezius worked synergistically with the prime mover to accomplish shoulder abduction. The isometric contraction, instead of dynamic contraction, was chosen in the current study because of the potential needle displacement out of the MTP during dynamic contraction of the upper trapezius muscle.

Palpation and Detection of MTP

A latent MTP was defined by the presence of a taut muscle band, local twitch response, and the most tender spot on digital palpation.[24] A non-MTP was defined by the absence of latent MTP characteristics. A latent MTP was further confirmed by the existence of spontaneous electrical activity (SEA), and a non-MTP was not showing SEA from intramuscular EMG recordings, as detailed later.

MVC Recordings

Middle deltoid muscle contraction force without needle in the muscle was measured using a force transducer mounted in custom-designed setups. Subjects were asked to maximally abduct the dominant shoulder for 3 seconds and repeated 3 times with 1-minute rest intervals between each repetition. The maximal force output of the 3 recordings was chosen as the value for the MVC.

EMG Recordings

A concentric intramuscular EMG needle (Ambu Neuroline Concentric, .25 $\times$ 45 mm; Ambu, Ballerup, Denmark) was inserted into a latent MTP or a non-MTP. A latent MTP was then confirmed by the presence of intramuscular SEA from the intramuscular EMG needle.[22,23,26] The procedure of searching for the SEA is similar to those reported previously.[14,22,23] The EMG needle was inserted at an angle of approximately 90° to the skin surface overlying an MTP (targeted to the nodule) for the first needle insertion. The second insertion was at an angle of approximately 80° directed proximally to the first track and for the third track was at 80° directed distally to the first track. Each advance continued until it encountered SEA with the amplitude of at least 50 μV when the muscle was at rest. On the contrary, a non-MTP was confirmed by the absence of SEA from the intramuscular EMG needle, which was placed in a non–taut-band muscle outside of the end plate zone (MTP region), 1 to 2 cm away from the site being examined.[14,22]

Following skin preparation, a pair of bipolar surface electrodes (Neuroline 720-01-k; Neuroline, Ølstykke, Denmark; intra-electrode distance of 2 cm) was placed 2 cm distal to the intramuscular EMG needle, and another 3 pairs of surface electrodes were placed on 1) the middle point of the middle deltoid; 2) the middle trapezius: approximately 20% medial to the midpoint between the medial border of the scapula and the T3