Original Article
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Medical Journal of the Islamic Republic of Iran (MJIRI)
Iran University of Medical Sciences

The effects of arm movement on reaction time in patients with latent and active upper trapezius myofascial trigger point

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Received: 6 May 2015 Accepted: 28 July 2015 Published: 16 November 2015

Abstract

Background: Myofascial pain syndrome is a significant source of mechanical pain. The aim of this study was to investigate the effects of arm movement on reaction time in females with latent and active upper trapezius myofascial trigger point.

Methods: In this interventional study, a convenience sample of fifteen women with one active MTP, fifteen women with one latent MTP in the upper trapezius, and fifteen normal healthy women were participated. Participants were asked to stand for 10 seconds in an erect standing position. Muscle reaction times were recorded including anterior deltoid (AD), cervical paraspinal (CP) lumbar paraspinal (LP), both of upper trapezius (UT), sternocleidomastoid (SCM) and medial head of gastrocnemius (GcM). Participants were asked to flex their arms in response to a sound stimulus preceded by a warning sound stimulus. Data were analyzed using one-way ANOVA Test.

Results: There was significant differences in motor time and reaction time between active and control groups ($p< 0.05$) except for GcM. There was no significant difference in motor time between active and passive groups except for UT without MTP and SCM ($p< 0.05$). Also, there were no significant differences in motor times between latent MTP and control groups. Furthermore, there was no significant difference in premotor times between the three groups.

Conclusion: The present study shows that patients with active MTP need more time to react to stimulus, but patients with latent MTP are similar to healthy subjects in the reaction time. Patients with active MTP had less compatibility with environmental stimulations, and they responded to a specific stimulation with variability in Surface Electromyography (SEMG).

Keywords: Myofascial trigger point, Surface Electromyography (SEMG), Reaction Time.

Cite this article as: Yassin M, Talebian S, Ebrahimi Takamjani I, Maroufi N, Ahmadi A, Sarrafzadeh J, Emrani A. The effects of arm movement on reaction time in patients with latent and active upper trapezius myofascial trigger point. *Med J Islam Repub Iran* 2015 (16 November). Vol. 29:295.

Introduction

Myofascial pain syndrome is considered to be one of the most frequent causes of muscular pain (1,2). Myofascial pain syndrome is considered by the presence of myofascial trigger points (MTP) on a sensitive spot in a taut band of skeletal muscle, which is painful on compression, generating motion and vegetative modifications. They are clinically classified as latent and active MTP. The etiology of the MTP is not presently known. The most known hypoth-

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esis focuses on the existence of dysfunctional endplates leading to a perpetuated shortening of the muscle (3,4). This hypothesis is established by the investigations of Shah et al (5,6). Studies focus the importance of the existence of latent muscular MTP because this can cause a possible dysfunction in the muscle activation pattern and could be an influential factor in the entrance of future injuries (7). Myofascial trigger points can be caused in many ways (8), one of which could be related to physical activities related with carrying light loads and certain postures such as those that are kept while working in front of a computer for long periods of time (9). Repeated muscle activity associated with certain positions could explain the presence of muscle pain in certain body parts, such as the neck (7).

Most of studies examined the effect of low back pain on the anticipatory postural adjustments (APAs) and reaction time. Jacobs et al investigated the low back pain (LBP) associated with altered postural stabilization. They showed that Cerebrocortical activity altered prior to arm movements requires APAs for individuals with chronic LBP (10,11).

Tsoa considered reorganization of the motor cortex that is associated with postural control deficits in recurrent low back pain. They observed that when LBP individuals moved their arm rapidly into flexion, activation of transverses abdominal EMG was significantly delayed compared to the healthy individuals (12). Although the nature and causes of back pain and neck pain vary, but it can be claimed that pain can change the muscle reaction time. The mechanism of adaptation to pain consists of alterations in motor cortex, excitability and organization (13).

In general, arm flexion was used to evaluate postural control therefore. We investigated arm flexion in patients with upper trapezius myofascial trigger point. Cervical and lumbar paraspinal were selected as postural muscles. Upper trapezius with MTP was selected as damaged muscle and another upper trapezius and sternocleidomastoid were chosen for investigation changes in synergist muscles group. Deltoid also, was selected as prime mover in this study.

Currently, there is no published paper on the effects of MTP on reaction times of muscles. The aim of the present study was to investigate the effects of arm flexion on reaction times of muscles in patients with active and latent myofascial trigger point and control group and to compare reaction times of muscles between three groups.

Methods

Subjects

In this interventional study, a convenience sample of fifteen women (aged 26.8± 5.94 years) with one active MTP and fifteen women (aged 27.53±3.73 years) with one latent MTP accessible in upper trapezius muscle and fifteen matching healthy control women (aged 27.73±3.43 years) were recruited. Participants were selected considering the inclusion and exclusion criteria (table 1,2) (14). They requested to sign the consent form approved by Tehran University of Medical Sciences ethics committee (approval number: 92/D/130/ 297).

Participants were investigated to make sure there was no severe postural disorders, no history of epilepsy, depression, migraine, and other mental health disorders, no history of surgery in the shoulder and cervical area in the past six months prior to these tests, no treatment of trigger point was performed in the past month prior to experiments, visual analogue scales (VAS) of two or three during the experiment period, no special sign of headache, dizziness, squint, and nausea during the movement or in the special positions, no symptoms of arthrogenic pain, osteoarthritis and radiculopathy of cervical area and upper limb, and disorders of temporomandibular joint (TMJ). The healthy participants should not have any active MTP in other muscles of their head and cervical region. On the day of experiment, participants should not consume any food or drink having caffeine,

such as coffee.

Participants who were in the period of menstrual cycle, those for whom appropriate recording of electromyography (EMG) and CNV had not been accomplished in the session of experiment, those who had pain in the cervical and shoulder area in the session of the test, or had used sleep aids and sedative drugs 24 hours prior to the experiment, and those who their cooperation with examiner had not been carried out because of pain and over exhausting were excluded from the study.

The existence of MTP in upper trapezius muscle was determined using the diagnostic measures including: presence of a palpable taut band, local twitch response activated by the snapping palpation of the taut band, presence of at least one hypersensitive tender point in the taut band in response to 25N of pressure, spontaneous presence of the typical referred pain pattern and/or patient recognition of the referred pain.

Equipment

1. *Force platform*: Participants were asked to stand on the force platform (Bertec Columbus, Ohio, USA) for 10 seconds in an erect comfortable standing position with feet 10 centimeter apart. The Force platform only is utilized for monitoring center of foot pressure (CFPy) displacement.

Whenever the CFPy displacement was around ±1 centimeters in anterior-posterior direction, the substantial steps of experiments were accomplished for participants (15).

In next step, participants were asked to stand in front of the designed system which was utilized for lifting the weight. Her shoulder was flexed to 60 degrees (16), elbow positioned extended and pronated.

This weight was set at 2% of the body weight and was hung from lower section of the designed system (15,16). To examine the movement initiation, a sensor was designed and as the weight was lifted off the sensor, a trigger was recorded by SEMG signal. Range of arm motion was calculated from the first height of the hands to shoulder height (15) (Fig. 1).

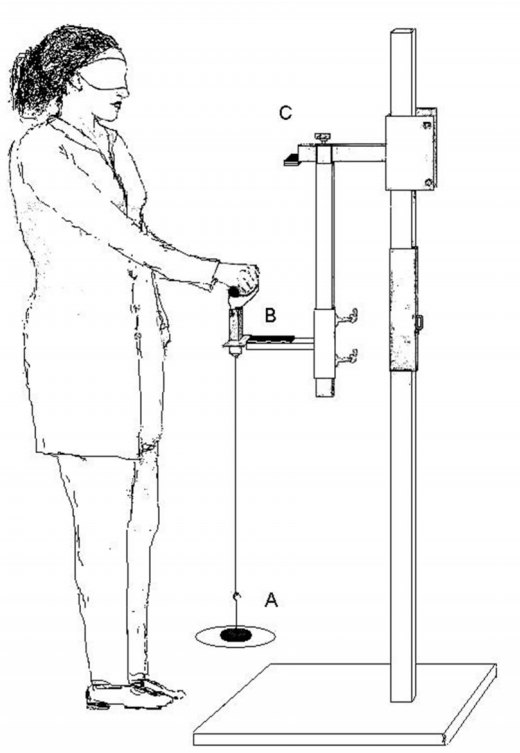

Fig. 1. Experimental setup (A= weight site, B= Onset trigger or 60 degree sensor (blacked plate), C: Offset or 90 degree sensor (blacked plate))

2. *SEMG*: SEMG equipment (Biometric Ltd, UK) with sampling rate: 1000Hz, band pass filtered: 20-450Hz and sensitivity: 100µv/div was used in this study. Placement of the electrodes was done according to the guideline of SENIAM: anterior deltoid (AD) at 2cm anterior and inferior of acromioclavicular joint; cervical erectrospinal (CE) at the level of the C4; lumbar erectrospinal (LE) at the level of the iliac crest; upper trapezius (UT) at the midway between acromioclavicular joint and C7; sternocleidomastoid (SCM) a third of the distance from sternal notch to mastoid processes; and the medial head of gastrocnemius (GC) (15-17).

Surface electrodes (Biometrics Ltd, UK) were set at fixed positions on shaved and cleansed skin (15). They were mounted in bipolar pattern and were allied along the major axis of the muscle with a 2 centime-

ters inter-electrode distance. All recordings were made from the involved side in the MTP group, and from dominant hand in the control group; both groups were matched in terms of dominant hand together.

Procedure

Participants were asked to stand in upright position on the force platform. At first stage participants were asked to stand for ten seconds with their hands at both sides of their body. This position was repeated 5 times with 30 seconds trial interval. At next stage, subjects stood on the force platform while their shoulder was positioned at 60 degrees. As soon as the displacement of the center of the foot pressure (CFPy) was around ±1 centimeters in anterior-posterior direction, the substantial steps of experiments were accomplished (15).

Two different tones were used as warning stimulus (S1) and response stimulus (S2). The interval between stimuli was introduced as the preparatory period, which was fixed at 2 seconds. The duration and frequency of auditory stimulus were equal to 100 milliseconds and 2 kHz, respectively. Intensity was set 50 dB higher than the hearing threshold (15,16).

Following three seconds quiet standing, S1 was presented followed by S2 after two seconds. Participants flexed their shoulder up 90 degree, as fast as possible to minimize response time to S2. This position was, then, held for about three seconds. Speed of movement was accentuated over precision (16). For recording and quantifying the speed, a sensor was placed on participant's shoulder. The initial position of the sensor was at 60 degrees of shoulder flexion which was shown by an event marker on SEMG signal. After the shoulder was flexed to 90 degrees, the end of motion was detected by an external sensor in synchronize with SEMG, it was estimated that shoulder flexion speed to be about 100 signals.

Analysis and Interpretation of Data

SEMG analysis: After signal filtering, RMS (Root Mean Square) values were calculated. Average amplitude of baseline activation was calculated for 500 milliseconds before S1. Afterwards average amplitude of baseline activity plus 3 standard deviations (SD) was used as a threshold of activity to determine the onset of muscle activation (18). All stages were performed using data log software and finally the SEMG output data consisted of onset of preparatory activity of muscles.

Reaction time of motion was interval between S2 and onset of motion. Onset of motion was calculated based on the triggering signal synchronized with SEMG signal. This variable consisted of pre-motor plus motor time. Pre-motor time was interval between S2 and onset of muscle electrical activity. Motor time was interval between the onset of electrical activity and the onset of motion.

Statistical Analysis

A Kolmogorov-Smirnov (K-S) test was used to determine the normal distribution of each variable. Analysis of variance (ANOVA) test was used to determine whether there was a difference among the 3 groups regarding age, weight and height, premotor time, motor time and reaction time. LSD test was used for post hoc comparison. $P<0.05$ was considered as significant. All statistical calculations were accomplished using SPSS version 17.

Results

No statistical difference was found between the three groups for mean age, weight, and height ($p> 0.05$); therefore participants were matched with each other to compare the results between the groups. Anthropometric characteristics of participants are listed in Table 1. The results of pain and pain pressure threshold (PPT) are listed in Table 2.

K-S test was not significant for all variables; therefore we could assume that all of variables is normal and a parametric one-way ANOVA test could be used.

Table 1. Anthropometric characteristics of participations in the control group (N=15), active MTP group (N=15) and latent MTP group (N=15) (mean ± SD)

Group	N	Age(y)	Weight (Kg)	Height (cm)
Control	15	27.73± 3.43	61.13± 6.55	162.00± 6.26
Active MTP	15	26.80± 2.67	57.07± 6.43	163.60± 5.94
Latent MTP	15	27.53±3.73	58.68±6.27	161.80±4.53

Table 2. Pain and PPT of participations in active MTP group (N=15) and latent MTP group (N=15) (mean ± SD)

Group	N	Pain (mm)	PPT ($N/^{m2}$)
Active MTP	15	65± 25.14	7.33± 3.99
Latent MTP	15	56.66±20.23	9.81±3.22

Table 3. Results of Premotor time and LSD Post hoc Test. (N=15) (mean ± SD)

Variables	Control group	Active MTP	Latent MTP	p
Pre motor time (AD	207.0±42.40	255.2±107.88	209.0±55.10	0.261
Pre motor time (CE)	217.2±57.78	237.6±85.29	227.9±61.28	0.719
Pre motor time (LE)	233.7±41.14	249.4±76.73	239.1±48.73	0.748
Pre motor time (UT)	228.9±61.24	268.9±130.84	264.0±78.10	0.445
Pre motor time (UT with MTP)	129.7±43.82	172.0±114.34	146.1±54.68	0.326
Pre motor time (SCM)	173.5±62.41	198.7±121.91	191.8±66.88	0.722
Pre motor time (GC)	194.7±78.75	241.0±107.88	225.6±57.14	0.312

1. Premotor Time

Results of ANOVA test indicated that there was no significant difference in premotor time between the three groups. Results of SEMG premotor times are presented in Table 3.

2. Motor Time

Results of ANOVA indicated that there was significant difference in motor time between the groups. Results of LSD post hoc test showed that motor time in active MTP had significant increase than latent MTP and control group ($p< 0.05$). Motor time in latent MTP was higher than control group but there was not any statistical difference ($p> 0.05$). However, there was no significant difference between latent MTP and control groups ($p> 0.05$). Motor time showed significant difference between latent and active MTP groups in SCM and UT without MTP ($p< 0.05$) but in other muscles there was not any significant difference ($p> 0.05$). MTP Results of SEMG motor times are presented in (Table 4) and (Fig. 2).

Table 4. Results of ANOVA test between 3 groups

Variables	p
Motor time (AD)	0.03
Motor time (CE)	0.013
Motor time (LE)	0.020
Motor time (UT)	0.039
Motor time (UT with MTP)	0.05
Motor time (SCM)	0.005
Motor time (GC)	0.67

3. Reaction Time

Results of ANOVA indicated that there was significant difference in motor time between the groups. Results of LSD post hoc test showed that reaction time in active MTP had significant increase than latent MTP and control group ($p< 0.05$).

Discussion

Premotor time of muscles' perceptual part of movement is one of the variables that have been investigated in this study. The results indicated that there was no significant difference between active MTP, latent MTP and healthy control groups. However, premotor time which is defined as incorporating perception, decision making and information processing and transfer (19), was increased in the MTP group. Absence of meaningful difference in this parameter between the groups may be due to lack of difference between receiving and processing of the information (19,20).

The time of movement is another variable that it is related to the rate of muscle force production and is also considered as an indirect measure of muscle–tendon unit stiffness (21).

In this study, time of movement showed

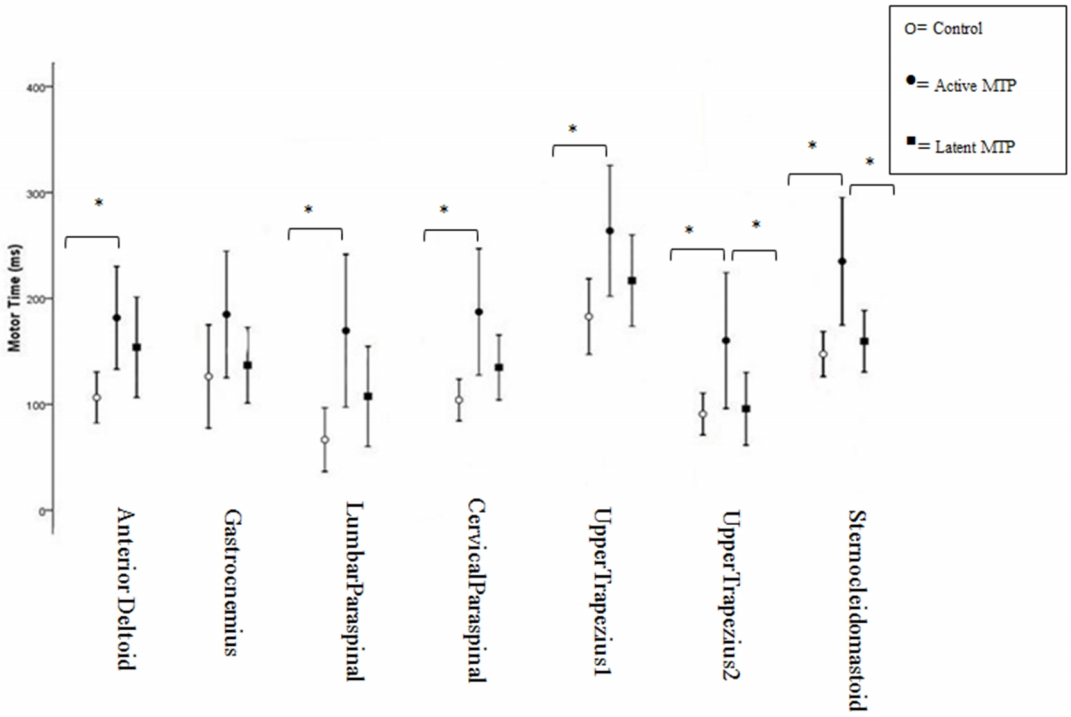

Fig. 2. Means and standard deviations of SEMG motor time. Asterisk indicates significant difference between the three groups ($p< 0.05$).

- Upper trapezius 1 as an upper trapezius with MTP in patient groups and as a dominant upper trapezius in control group.
- Upper trapezius 2 as an upper trapezius without MTP in patient groups and as a non-dominant upper trapezius in control group.

an increasing trend in patients' group, which is in agreement with high irritability of CNS (22). It can be claimed that patients with high irritability may have encountered higher inputs that caused an increase in motor response and time of movement (3,22). It is proved that the patients with trigger points have disorders in motor control at the level of limbic system, especially at planning level (23); then abnormal response to peripheral stimulation can be attributed to disturbance in information processing (20). Although, motor time showed increasing trend in latent MTP group than the control group but this increase was not statistically significant.

Another variable is the reaction time of muscles that showed an increasing trend in patients' group. This increase can be attributed to the reduction in neuromuscular control in patients' group. The reduction in neuromuscular control or neuromuscular coincidence may result from an increase in cervical muscle tone due to the trigger point (3,22,24). Moreover, there is an increase in sympathetic response in patients with trigger point (22,25,26). This element can increase cutaneous afferent input which finally affects gamma fusimotor in muscle spindle and cervical proprioception (22,27,28).

Most of studies examined the effect of low back pain on the anticipatory postural adjustments (APAs) and reaction time. Jacobs et al investigated the low back pain (LBP) associated with altered postural stabilization and concomitant changes in the cerebrocortical motor physiology.

They showed that cerebrocortical activity altered prior to arm movements requires APAs for individuals with chronic LBP. In this study, increasing reaction time due to pain is in agreement with Jacobs, et al findings (10,11).

Yassin et al. considered effects of arm flexion on reaction time in patients with

active MTP. They observed, that when MTP individuals moved their arm rapidly into flexion, activation of all of muscles except for GcM were significantly delayed compared to the healthy individuals (12). Therefore, it could be claimed that pain can change the muscle reaction time (20).

The results showed that muscle reaction time was not changed in latent MTP group. Therefore, these patients were similar to normal participants in reaction time and onset of muscles time. There is no difference between the latent MTP and control group that may be due to the pain in active MTP group. The new theory of pain expresses the hypothesis of accordance which is attributed to pain in the motor and sensory function. The changes in motor function consists of alterations that occur in the excitability and organization of the motor cortex (13), also induces more complicated changes that occur in the motor responses and repairing motor cortex (29). The changes in sensory function include reduced sensory perception (30), increased repositioning errors (31), and reduced responsiveness to sensory input (32). Changes in the sensory function can deeply affect the movement control of the musculoskeletal system, especially in painful conditions (33,34), and reduced sensory processing before modulation of motor output (34).

In general, in active MTP patients after each stimulus, more time is needed for CNS to accept the new stimulus. The process of hyperactivity in control centers leads to lack of self- regulation which finally results in the application of an unusual muscular pattern or different co-activation (22,35). This behavior can undoubtedly affect the parameters of reaction and movement control (10,36). This can be regarded as one of the most important results in this study; after applying a particular stimulus, individuals can be expected to respond correctly. However, it takes a long time for CNS to react; consequently the extent of coincidence declines. This occurrence is because of reducing the habituation of the control system after applying a specific motor command (10,36). Patients involve more sources of attention and then it led to abundance degree of freedom (34,37,38). So increase of degree of freedom can cause variation of muscular behavior and reaction time (37).

Limitations

This study was only carried out on female participants and sample size is small, therefore the results from this study could not be extrapolated to males.

Clinical significance

MTP is not just contracted muscle fibers but neuromuscular lesions that form part of a neurological loop that affects and is affected by the CNS. MTP in the arm flexor muscles is changed the muscle activation pattern. The presence of MTP in the arm flexor muscles is associated with changes in motor control. The changes described above may predispose individuals to increased risk of overuse Tendinitis, overuse MTP of the non- dominant upper trapezius, SCM and decreased efficiency of movement during arm flexion.

Conclusion

Firstly patients had less compatibility with environmental stimulations, and secondly, they responded to a specific stimulation with many degrees of freedom and variability in SEMG. Although, patients with latent MTP are same as control group in responding to stimulus but, it may be as a result of compensatory increase of motor time in SCM and UT. According to the results of this study, it can be concluded that use of motor control techniques in this type of patients might be useful.

Suggestion for future studies

Because all of postural muscles were not evaluated and only women were recruited, performing new research in both sexes and considering other muscles is proposed. Also, investigation parts of brain with electroencephalography (EEG) or Contingent Negative Variation (CNV) synchronize

with SEMG in MTP groups is proposed.

Conflicts of Interest

The authors have no conflict of interest to disclose.

Acknowledgments

This study was supported by Tehran University of Medical Sciences (TUMS). The authors would like to appreciate the assistance of the faculty and the staff of the TUMS and Iran University Medical Science (IUMS) school of Rehabilitation.

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