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Arm Flexion Influence on Muscle Reaction Time in Females with Active Myofascial Trigger Point

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Authors' contributions

This work was carried out in collaboration between all authors. Authors MY and ST designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript and managed literature searches. Authors IET, NM, AA, JS, SJ and AE managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To investigate arm flexion effect on reaction time in females with upper trapezius active myofascial trigger point (MTP).
Methods: Fifteen women (aged 24.5±2.7 years) with one active MTP in the upper trapezius and fifteen normal healthy women (aged 23.30±1.6 years) participated in this study. Participants were

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asked to stand on the force platform for 10 seconds in an erect comfortable standing position. To investigate muscle reaction time, time interval of first stimulus presentation and muscle force generation onset were measured. The target muscles were anterior deltoid (AD), cervical Paraspinal (CP) lumbar Paraspinal (LP), upper trapezius (UT), sternocleidomastoid (SCM), medial head of gastrocnemius (GC). Participants were asked to flex their arms in response to a sound stimulus preceded by warning sound stimulus.

Results: There were significant differences between test and control subjects in reaction and motor time ($P < 0.001$). There was no significant difference between these groups in premotor time.

Conclusion: The present study showed that patients with active MTP needed more time to react to stimulus. Firstly, patients had less compatibility with environmental stimulations, and secondly, they responded to a specific stimulation with variability in Surface Electromyography (SEMG).

Keywords: Myofascial trigger point; surface electromyography; reaction Time.

1. INTRODUCTION

Mechanical pain is a general term referring to any type of back pain caused by placing abnormal stress and strain on muscles of the vertebral column. Typically, mechanical pain results from bad habits, such as poor posture, poorly-designed seating, and incorrect bending and lifting motions [1,2]. An etiology of mechanical pain is not well understood, but the literature indicates that shoulder and cervical region myofascial trigger point (MTP) could be responsible for this category of mechanical pain [3]. MTP as a significant source of mechanical pain [1,4] has a high prevalence among individuals with regional pain complaints [3]. The prevalence differs from 21 percent in patients perceived in general orthopedic clinics, to 30 percent in general medical clinic patients with regional pain and up to 85 - 93 percent of patients in specialty pain management center [4].

The mechanism of adaptation to pain consists of alterations in motor cortex, excitability and organization [5]. Furthermore, it comprises of more complicated changes in sensory input and motor responses [6]. Changes in sensory function can deeply affect movement control of musculoskeletal system, especially in painful conditions [7,8]. There are numerous studies about sensory changes following pain in shoulder [9], back [10] and cervical pain [11]. The changes include reduced sensory perception[12], increased repositioning errors [13], reduced responsiveness to sensory input [14], and restructuring of the somatosensory areas of the motor cortex [15,16]. These studies indicate that pain induces changes in Central Nervous System (CNS), which possibly leads to complex changes in movement and postural control mechanism.

Reaction time includes two critical phases: the premotor time and motor time [17]. The premotor time is defined as the time between exhibition of a stimulus and the first noticeable muscle activity, incorporating perception, decision making, information processing and transfer [17,18]. The motor time which is also called electromechanical delay is defined as the time between muscle activity onset and force generation [17]. It is related to the rate of muscle force production and is also as an indirect amount of muscle–tendon unit stiffness [19].

As there is no published paper about effects of MTP on muscle reaction time, the aim of the present study was to investigate the effects of arm flexion on reaction time of muscles in females with active myofascial trigger point. Our primary hypothesis claims that MTP can affect the muscle reaction time. The secondary hypothesis is increasing the reaction time due to pain.

2. METHODS

2.1 Subjects

This study is an original research. A convenience sample of fifteen women (aged 24.5±2.7 years) with one MTP accessible in upper trapezius muscle together with fifteen matching healthy control women (aged 23.30±1.6 years) were recruited.

The subjects were found to be suitable for participation in this study due to a good match with the inclusion and exclusion criteria (Tables 1 and 2) [20,21]. The subjects were requested to sign the consent form approved by Tehran University of Medical Sciences ethics committee. The approval number was 92/D/130/297.

A MTP was considered as active if all of the aforesaid criteria were present [22].

Table 1. Inclusion criteria

- Presence of a palpable taut band.
- Local twitch response activated by snapping palpation of the taut band.
- Presence of at least one hypersensitive tender point in response to 25 newton pressure on taut band.
- Spontaneous referral pain pattern [21,22].
- Visual Analogue Scale (VAS) is two or three centimeters during the experiment period.

Table 2. Exclusion criteria

- Severe postural disorders in clinical assessment.
- History of epilepsy, depression, migraine, and other mental health disorders.
- History of surgery in the shoulder and cervical area during the past six months prior to these tests.
- Treatment of trigger point in the past month prior to experiment.
- Sign of headache, dizziness, squint, and nausea during the movement or in positions.
- Clinical symptom of osteoarthritis and radiculopathy of cervical area and upper limb.
- Sign of fibromyalgia.
- Temporomandibular joint (TMJ) disorder in clinical assessment.
- Caffeine consumption on the test day.
- Participant in the menstrual cycle.
- Lack of appropriate report of SEMG.
- Lack of cooperation because of pain and exhaustion.

2.2 Equipment

2.2.1 SEMG

SEMG equipment (Biometric Ltd, UK) with sampling rate: 1000 Hz, Band pass filtered: 20-450Hz and sensitivity: 100μv/div was used in this study. Placement of the electrodes followed the guideline of SENIAM: anterior deltoid (AD), lumbar paraspinal (LP) at the level of the iliac crest, upper trapezius (UT) at the midway between acromioclavicular joint and C7, and the medial head of gastrocnemius (GC) [23-25]. Cervical Paraspinal (CP) at the level of the C4 [26,27] and sternocleidomastoid (SCM) a third of the distance from sternal notch to mastoid processes [26-29]. Surface electrodes (Biometrics Ltd, UK) were set at fixed positions on shaved and cleansed skin [24]. They were mounted in bipolar pattern and were allied along the major axis of the muscle with a 2 centimeters inter-electrode distance. All recordings were made of the involved side in the MTP group, and from dominant hand in the control group. Both groups were matched in terms of dominant hand.

2.3 Procedure

At the first stage, participants maintained upright on force platform (BertecColumbus, Ohio, USA) for 10 seconds in an erect comfortable standing position with feet 10 centimeter apart. The Force platform only was utilized for monitoring center of foot pressure (CFPy) displacement [24]. The test was started as soon as CFPy displacement was around ±1 centimeter [24].

In the next step, participants were asked to stand in front of the designed system for weight lifting. Subject's shoulder was flexed to 60 degrees [23], elbow was positioned extended and pronated. Weight set at 2% of body weight was hung from lower section of system [23,24]. A sensor was designed to examine the movement initiation. As soon as the weight was lifted off the sensor, a trigger was recorded by SEMG signal. Range of arm motion was calculated using the first height of the hands to shoulder height [24] (Fig. 1).

Two different tones were used as warning stimulus (S1) and response stimulus (S2). The interval between stimuli fixed at two seconds, was introduced as preparatory period. The duration and frequency of auditory stimulus were equal to 100 milliseconds and 2 kHz, respectively. Intensity was set at 50 dB higher than hearing threshold [23,24].

Following three seconds quiet standing, S1 was presented followed by S2 after two seconds. Participants were asked to flex their shoulder as fast as conceivable to minimize the response time to onset of S2, stopping hand at shoulder level. This position was then held for three seconds. Speed of movement was accentuated over precision [23]. In order to record and quantify the speed, a sensor was placed on participant's shoulder. The initial position of the sensor was at 60 degrees shoulder flexion. It was shown by an event marker on SEMG signal. After the shoulder was flexed to 90 degrees, end range of motion was detected by an external sensor in synchronized with SEMG after ten repetitions.

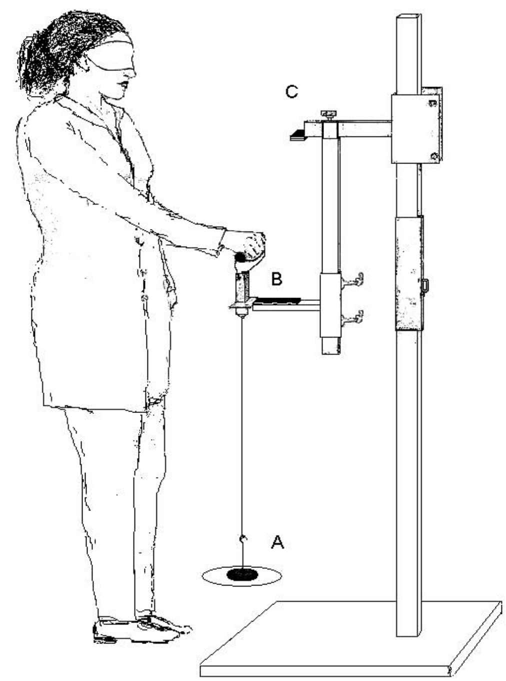

Fig. 1. Experimental setup
A = Weight site; B = Onset trigger or 60 degree sensor (Black plate); C = Offset or 90 degree sensor (Black plate)

2.4 Analysis and Interpretation of Data

2.4.1 SEMG analysis

Following signal filtering, Root Mean Square (RMS) values were calculated. Average amplitude of baseline activation was calculated based on 500 milliseconds before S1. Afterwards, the average amplitude of baseline activity plus 3 standard deviations(SD) were used as activity threshold to determine the onset of muscle activation [30]. All stages were performed by data log software and finally the SEMG output data consisted of onset of preparatory muscle activity.

The interval between S2 and onset of motion was considered as the reaction time. It was motion onset that calculated based on the triggering signal synchronized with SEMG signal. This variable also included premotor time (interval between S2 and onset of muscle electrical activity).

2.5 Statistical Analysis

A Kolmogorov-Smirnov (K-S) test was used to determine the normal distribution of each variable.

Independent *t*- test was used to investigate the matching accuracy of demographic criteria and to compare the variables between two groups. The confidence level was set at $\alpha < 0.05$ for statistical significance. All statistical calculations were accomplished by SPSS statistical software, version 17.0.

3. RESULTS

No statistical difference was found between two groups for mean age, weight, and height. In other words, participants were matched. Anthropometric characteristics of participants are listed in Table 3.

K-S test result was not significant for all variables. Therefore, all variables were assumed as normal, and a parametric t-*test* was used.

3.1 Premotor Time

There was no significant difference in premotor time in all muscles between the control and MTP group. Independent *t*-test results of SEMG premotor times are presented in Table 4.

Table 3. Anthropometric characteristics of participations in the control group (N=15) and MTP group (N=15) (mean±SD)

Group	N	Age(y)	Weight (Kg)	Height (cm)
Control	15	23.30±1.6	56.53±6.2	164.76±6.45
MTP	15	24.50±2.7	57.50±5.47	163.35±5.4

Table 4. The results of premotor time, (N=15 and Mean±SD)

Variables	Control group (mean± SD)	MTP group (mean± SD)	P- value (T-test)
Premotor time (AD)	211.33±40.48	256.79±144.46	0.259
Premotor time (CP)	219.85±59.13	240.77±87.32	0.460
Premotor time (LP)	235.47±42.13	235.31±77.77	0.454
Premotor time (UT1)	132.31±44.22	175.75±117.35	0.198
Premotor time (UT2)	234.45±59.46	271.46±130.84	0.333
Premotor time (SCM)	179.90±59.45	202.08±125.39	0.545
Premotor time (GC)	169.97±81.21	245.245±110.30	0.193

Anterior Deltoid (AD), Cervical Paraspinal (CP), Lumbar Paraspinal (LP), Upper Trapezius (UT), Sternocleidomastoid (SCM), Gastrocnemius (GC)

- *Upper trapezius1 was considered as the upper trapezius with MTP in patient group and as a dominant upper trapezius in control group*
- *Upper trapezius2 was considered as the upper trapezius without MTP in patient group and as a non-dominant upper trapezius in control group*

3.2 Motor Time

Except for the gastrocnemius, motor time in all other muscles showed significant differences ($P < 0.05$) with MTP group showing higher motor time than the control group. Independent *t*-test results of SEMG motor times are presented in Fig. 2.

3.3 Muscle Reaction Time

There was significant difference observed in reaction time between two groups ($P < 0.05$); the muscle reaction time was higher in patient group, compared to the control group.

4. DISCUSSION

Results of premotor muscle time as one of the variables indicated no significant difference between MTP and healthy control groups. However, the premotor times defined as the incorporating perception, decision making, information processing and transfer [17], were increased in MTP group. Absence of meaningful difference in this parameter between two groups may be due to lack of enough information in receiving and processing [17,18,31].

Movement time as a variable relating to muscle force production rate was also considered as an indirect measure of muscle–tendon unit stiffness [19].

In this study, time of movement showed an increasing trend in patients' group, which was in agreement with variations in arousal level of CNS, growth in CNS parameters and response stimulus [32]. It could be claimed that patients with high irritability may had encountered higher inputs causing an increase in motor response and movement time [2,32]. The first reasoning for abnormal response to peripheral stimulation could be attributed to disturbance in information processing. It was verified that the patients with trigger points had disorders in motor control at level of limbic system, especially at planning level [33]. Muscle reaction time showed an increasing trend in patients' group. This increase could be attributed to neuromuscular control reduction in this group.

The probable reason for such a reduction may be cervical muscle tone increase due to trigger point [2,4]. Moreover, the reported increase of sympathetic response in patients with trigger point [32,34-35] could be due to cutaneous afferent input increase which finally affects gamma fusimotor in muscle spindle and cervical proprioception [1,32,36].

Most studies had examined the low back pain effect on reaction time and on the other hand, there was no published paper in our study subject. Therefore, we had to use low back studies for comparison. 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 anticipatory postural adjustment for individuals with chronic LBP. The results demonstrated that the participants with LBP exhibited a significant difference in their onset latencies of their contralateral erectrospinal muscle, which was not evident from the participants without LBP. In our study, increasing reaction time due to pain was in agreement with Jacobs et al, findings [37,38].

Tsoa [39], considered reorganization of the motor cortex that associated with postural control deficits in recurrent LBP. They observed, when LBP individuals moved their arm rapidly into flexion, activation of transverses abdominal SEMG was significantly delayed compared to the healthy individuals [39]. Despite differences in nature and causes of back and neck pain, it could be claimed that pain could change the muscle reaction time.

In general, in MTP patients after each stimulus, more time was needed for CNS to accept the new stimulus. The process of hyperactivity in control center led to lack of self- regulation which finally resulted in the application of an unusual muscular pattern or different co-activation [32, 40]. This behavior could undoubtedly affect the parameters of reaction and movement control [37,41]. This could be regarded as one of the most important results in this study. In other words, following each particular stimulus, individuals could be expected to respond correctly. However, it took long time for CNS to react; consequently the extent of coincidence declined. This occurrence was because of reducing control system habituation after applying a specific motor command [37,41]. In other words involvement of more source of attention will lead to abundant degree of freedom [8,42,43]. So, degree of freedom increase could cause variation of muscular behavior and reaction time [42].

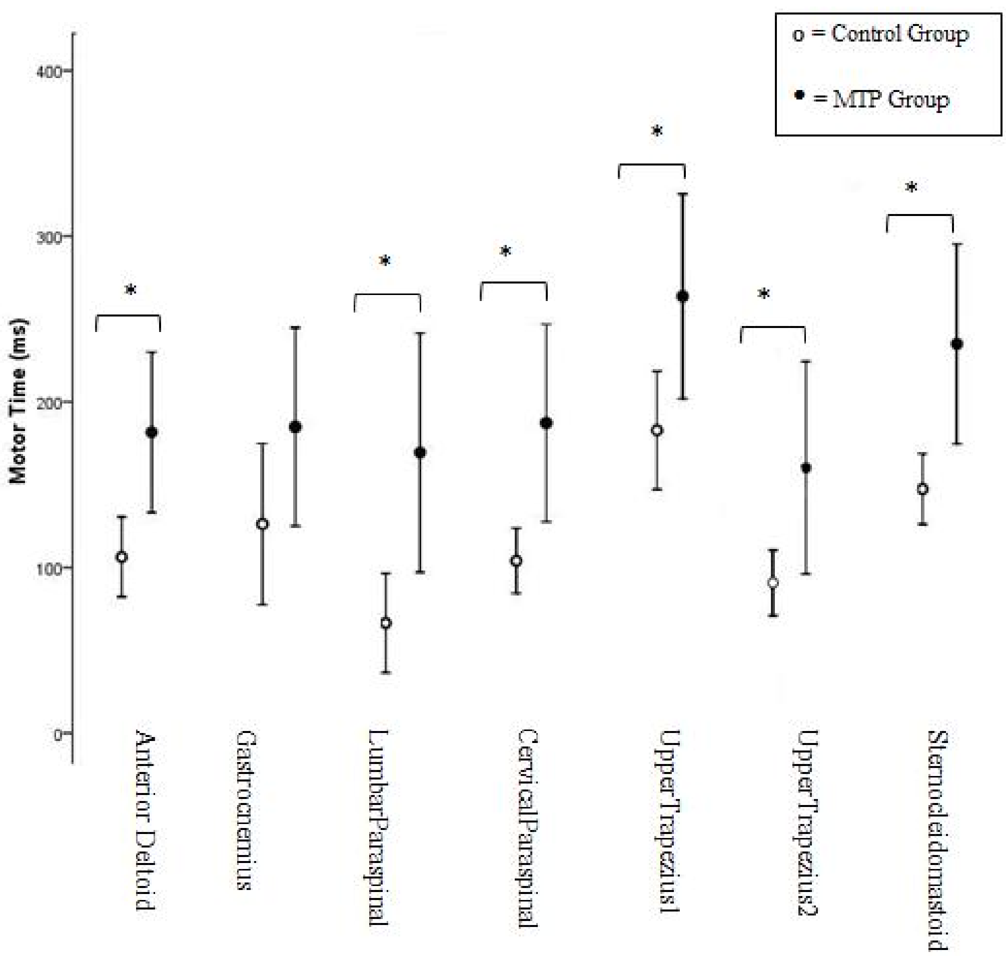

Fig. 2. Mean of SEMG motor time

Asterisk indicates significant difference (P < 0.05);

- *Upper trapezius1 was considered as the upper trapezius with MTP in patient group and as a dominant upper trapezius in control group;*
- *Upper trapezius2 was considered as the upper trapezius without MTP in patient group and as a non-dominant upper trapezius in control group*

5. STUDY LIMITATIONS

This study was carried out only on female participants and the sample size was small. Therefore, the results from this study cannot be extrapolated to males.

6. 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. 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.

7. SUGGESTION FOR FUTURE STUDIES

Performing new research in both sexes and considering another muscle is proposed. Besides, investigating the parts of brain with electroencephalography (EEG) or Contingent Negative Variation (CNV) synchronized with SEMG in MTP groups is proposed.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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