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Effect of Muscle Fatigue on the Upper Trapezius Muscle With and Without Myofascial Trigger Points in Students With Neck Pain: A Randomized Controlled Clinical Trial

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Abstract

Objectives: The purpose of this work was to explore cervical position sense and electromyographic (EMG) responses of cervical muscles during head repositioning movements in students with and without upper trapezius muscle trigger points.

Materials and Methods: Forty-six right-handed men and women subjects without upper extremity disorders participated in this study. The maximal voluntary contraction (MVC) was measured three time before the fatigue test. A force gauge was used to measure force while recording with a monitor. Measurement was initiated with a MVC force before and after fatigue pain and head positioning were measured. When the protocol was accomplished, the subjects showed signs of exhaustion; however, they were not subjectively evaluated for fatigue. As the protocol aimed at assessing muscle fatigue, a force level of 80% MVC was induced.

Results: These findings support the argument that the precision of the neck position sense can be reduced by the fatigue of the neck muscle. Fatigue impaired balance in the trapezius muscles. After removing vision this resulted in an increased center of pressure excursions on a force platform. Motor control did not change significantly in this study.

Conclusions: Fatigue had a more significant effect on cervical kinematics in the healthy subjects, probably due to the fact that altered neck motor control in volunteers implied that these individuals were not completely able to make up for fatigue of the neck muscle. Significant pain and head positioning changes were identified following fatigue applied to the pre-determined myofascial trigger points, but the changes were insignificant in the sham control group.

Keywords: Shoulder muscle, Electromyography, Fatigue, Myofascial trigger points

Introduction

Pain in the neck and shoulders is a prevalent musculoskeletal problem, particularly among employed people whose most common complaints are pain and increased muscle tension in the upper trapezius (1,2). In myofascial pain syndrome, pain originates from trigger points, defined as very sensitive areas in taut bands of skeletal muscle (3). Myofascial trigger points are described as a painful tender point of a skeletal muscle due to stretching, contraction, or compression within a taut band. After causing a reaction, result in a distant pattern of pain from that point. The maximum usually diagnosed myofascial trigger points within the frame are found in the higher trapezius muscle. The upper trapezius muscle is a sensitive area that has the smallest pressure pain threshold (PPT) measured by a pressure algometer. The muscle with the highest sensitivity in the body is the upper trapezius muscle. It also has the lowest PPT to the pressure of an algometer. It could be a result of the continuous work of the upper trapezius muscle against gravity, to maintain the neck and head vertical and eyes level in an upright posture (4).

There is little interventional research addressing motor control in neck pain patients. O'Leary et al concluded that cervical motor control changes depended on trainings, but various modes of training had comparable effects on neck pain and impairment (5,6).

Nevertheless, pain can also play a significant role in regulating muscle spindle discharge (6,7) or the nervous system output (8,9). To this point, the electromyographic (EMG) responses at some point of the repositioning movements have not been dealt with in young populations with neck pain (10).

It has been suggested that fatigue of the neck musculature alters the higher limb proprioception, motor styles, and kinematics (11).

Materials and Methods

The current research study is a randomized controlled clinical trial. The research sample consisted of students and patients with neck pain referring to the physical therapy clinic of the faculty of rehabilitation**.** Sixty-four right-handed subjects without upper extremity disorders included in this study. The control group served as a

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Key Messages

The results of this study could support evidence of the benefits of fatigue which includes the following:

- The behavior of the upper trapezius muscle was seen to be similar when assessment was based on the MF slope coefficient (negative slope coefficient).
- The behavior of the upper trapezius muscle was seen to be similar when the assessment was based on the RMS value (negative slope coefficient for the upper trapezius muscle).
- Force values as¬sociated with fatigue indices (MF and RMS slope) were able to predict the presence of pain in the upper trapezius.

placebo group to eliminate the possible soothing effect of skin pressure. An independent sample t-test was utilized to match age, weight, height, and body mass index (BMI).

All contributors had been recruited through announcements and were interviewed and examined prior to enrollment. The subjects were selected from Tehran University of Medical Sciences students who had no previous history of neck or shoulder pain the year before the present research, this study from 2017-2018.

Volunteers were randomly divided into the treatment group (n=32) receiving fatigue and the control group (n=32).

Absolute, Constant, and Variable Errors

The precision of the angle reproduction was quantified by means of 3 parameters for every one of the situations (12). To assess the path and value of the position error, the subsequent parameters were measured:

1. Absolute error is defined as the general deviation among a provided perspective and goal attitudes irrespective of the route of errors.
2. The variable error is described as a degree of consistency between trials and the SD of the implied constant errors.
3. Constant error is defined as the deviation among the provided and reproduced attitudes, regarding the route of error.

The commonality of the three trials in each group was employed to measure these errors. It was hypothesized that participants with upper trapezius muscle trigger points should show altered head and neck kinematics with respect to controls. That cervical muscle fatigue would modify kinematics variously in the subclinical neck pain group.

The aim of the current paper was to explore, the effect of fatigue on the upper trapezius in students with and without upper trapezius muscle trigger points.

Inclusion and Exclusion Criteria

All subjects were assessed for the existence of Latent trigger points to ensure they all had at least one latent myofascial trigger point in their dominant side upper trapezius muscles. All of the subjects – control and interventional groups – were right-handed. Flowchart of general research design and the number of subjects for every stage of the research is shown in Figure 1.

Participants were selected according to these inclusion criteria:

1. Experiencing neck pain no less than three months
2. Presence of a tender spot in the taut band of the upper trapezius muscle with palpation.
3. Showing a positive Jump sign in response to manual pressure applied to the trigger factor, the Jump sign is the problem's reaction to compression and is described as jumping far away from the examiner or showing facial expression (13).
4. Producing familiar pattern of pain and showing pain intensity <3 on a visual analogue scale (VAS)

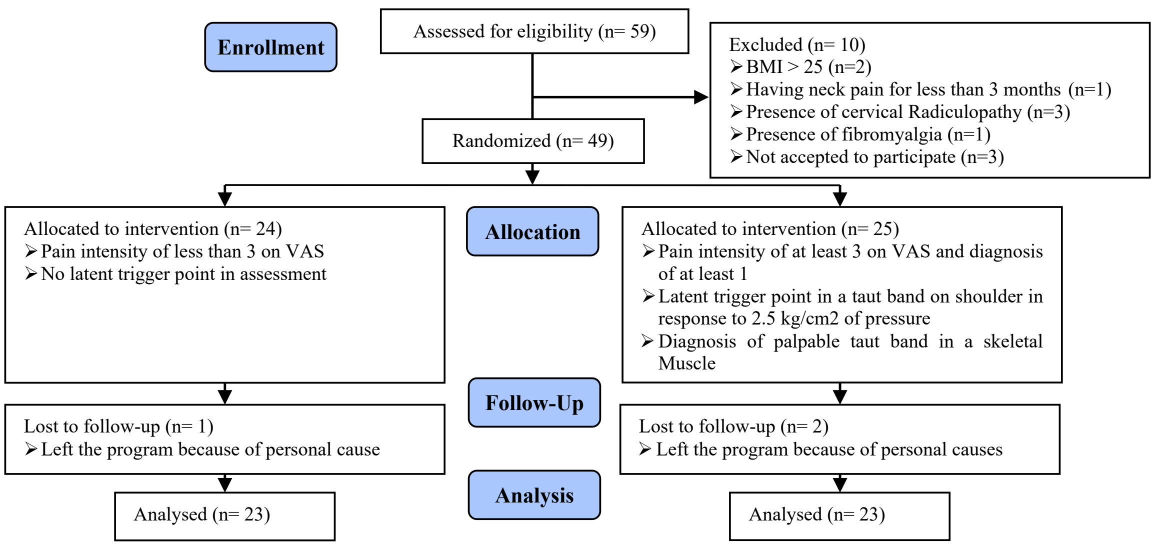

Figure 1. The Study CONSORT Flowchart.

graded from 0 (no pain) to 10 (worst pain possible) (14, 15).

The test was performed at individual active trigger points with a 2.5 kg/cm^2 pressure on a marked point by means of an algometer (JTECH Medical, US) (16).

In addition, the following were the exclusion criteria when selecting the participants:

1. Diagnosis of fibromyalgia syndrome (17).
2. History of surgery. Records of shoulder or cervical and radiculopathy (14).
3. History of trauma, fracture and disc disease or degenerative disease in cervical vertebrae (16).

The intensity of pain in the neck pain group was evaluated using a numerical rating scale. This scale consists of 11 points ranging from 0 (absence of pain) to 100 (worst possible pain). The cervical spine movements were determined by applying a range of motion instruments (Model: CROM Basic, Performance Attainment Associates, Roseville, Minnesota, United States). It consists of two gravity goniometers and a compass goniometer and is dependable instrument with acceptable validity.

The device was positioned on top of the interventional groups' head; the interventional group was then asked to move their head as much as possible, with no feeling of pain, in a standard manner: right rotation, left rotation, flexion, extension, right lateral flexion, and left lateral flexion. Three trials were carried out randomly for each direction, and the mean values were analyzed.

Measures

Surface EMG Recordings

Eight-channel EMG system (DataLog P3 x 8, Biometrics Ltd., Gwent, UK) (CMRR: 496 dB at 60 Hz, input impedance 41012 Ω, gain: 1000, band-pass filter: 20 Hz low cut-off, 450 Hz high cut-off). Electrodes: integral dry reusable electrodes (SX230, Biometrics Ltd, Gwent, UK) (Diameter: 10 mm, bipolar configuration and inter electrode distance: 20 mm). The electrode was positioned 2 cm lateral to the middle of the line between the C7 spinous process and the acromion (17,18). The inter-electrode distance (center to center) was 20 mm. Before placing the electrode, the skin was shaved and washed with 70% alcohol pads to lower skin impedance. A sampling rate of 1000 Hz and a filtered bandpass at 20-480 Hz (amplified with a common-mode rejection ratio >110 dB, overall gain 1000, noise <1 mV root mean square (RMS) were used. Surface recording electrodes were placed over the muscles following Cram et al (19), while the ground electrode was placed on the ipsilateral wrist. For the sake of adequate surface contact and reduced skin resistance, the skin was prepared for each electrode location following a standard procedure including disinfection, shaving, and abrading. Pre-gelled self-adhesive surface electrodes (Biometrics Ltd, electrode model SX230, 20-38 mm) were placed over the belly of the experimental muscles and aligned with their fibers' orientation on the dominant side of the subjects (20,21).

Interventions

The critiques were executed with the affected person seated simply on a chair with both feet flat at the digital balance, hips and knees flexed at 90°, buttocks positioned in opposition to the chair, and handled shoulder unclothed. Volunteers were asked to take a seat on a chair in an upright position with comfy hands positioned at the edges of their bodies. The head was maintained similarly to the trunk and the vertebral column. The subjects were asked to look ahead during the test without any cervical or trunk rotation, extension, or flexion. A good interexaminer reliability (k) ranging from 0.84 to 0.88 was found for the above-mentioned criteria (22).

Prior to the fatigue test, the maximal voluntary contraction (MVC) was measured three times. Each test lasted for about 10 seconds, and an interval of 20 seconds was maintained between the tests. At 80% of the MVC, calculation of submaximal level was performed using the highest value obtained. Two minutes after performing the last MVC test, the fatigue test was conducted. The method included isometric contractions of the upper trapezius muscle on the subject's dominant side. Even during the experiment, the participants sat on a height-adjustable chair. Pressure sensors were positioned on both shoulders; until they touched the acromion. These procedures were carried out while the participants were sitting in a relaxed position with hanging arms. While maintaining the contractions of the trapezius, a shoulder elevation was performed by the subjects against the force transducers, with the arms hanging passively along the body.

A force gauge (5020 model, Taiwan) was used for force measurement while being recorded with a PC (sampling rate 100 Hz). Measurement was initiated with a MVC force of the trapezius. Here, the subjects managed to conduct a dominant shoulder elevation against the force transducer, using as much force as possible and for at least 10 seconds. The experimental protocol was replicated three times with 20 s breaks. The MVC was regarded as the highest force value. After observing a 5 min break, a sustained submaximal contraction of the trapezius was conducted. The participants maintained a unilateral 80% MVC isometric shoulder elevation until the force gauge monitor displayed 50% MVC in at least 3 minutes. Force level feedback was provided. At the point of initiation and after each minute of contraction, the perceived exertion was rated. The force and EMG signals were recorded during MVC and sustained contractions. The participants were encouraged verbally during the MVC and the fatigue test. Although fatigue was not assessed subjectively, they showed exhaustion by the time the protocol ended. The force level corresponding to 80% of the MVC was selected as the protocol was intended to trigger muscle fatigue.

Data Analysis

SPSS software (version 21) was used to analyze the data, and the one-sample Kolmogorov-Smirnov test was applied to evaluate the normal distribution of the data. Based on the obtained data, the distribution of all variables was normal ($P > 0.05$). Repeated-measured tests demonstrated a statistically significant difference in the variables before, immediately, and 24 hours after the intervention in the study group. The significance level was set at $P < 0.05$.

Results

Two-sample *t* tests for data with unequal variances were performed to assess the fatigue. Descriptive information primarily based on class (control and interventional group) and fatigue (before and after) is shown in Figure 2; this shows errors in healthy and interventional group subjects. The study showed an improvement in repositioning error in the neck, but it was not significant. Fatigue also improved kinesthesia in both groups, but the change was insignificant (P>0.005). The control group was significantly higher at reproducing the neck target angle at baseline. The absolute and relative errors of the trigger point group showed a significant improvement after the cervical adjustments, but there is a significant overall effect in variable error. Tables 1 and 2 show these effects.

Discussion

Joint Position Sense Error

The mechanisms of producing the position sense were explored through a tendon vibration and muscle fatigue inside the joints at the wrist and elbow. Research on tendon vibration suggests that the joint's role is decided by integrating afferent alerts from the muscle spindles of antagonistic muscular tissues (19,20). Moreover, it should be noted that the position sense declined, although the shortening muscle in the course of the position sense dimension concerned muscle fatigue (21-25). Therefore, these studies strengthen the argument that the integration of afferent signals from the muscle spindles of the antagonistic muscles is of great significance when producing the position sense (21). The effort required to maintain the limb position is modified via fatigue. Every time a try is made with the fatigued limb, to move, the altered sense of function makes it hard to achieve the desired joint position (23). Three test protocols so far have studied joint repositioning error as a quantitative measure of kinesthesia (22). Fatigue impaired balance in the levator scapula and trapezius muscles. After removing vision, this resulted in an increased center of pressure excursions on a force platform (26,27).

Motor Control

Due to having the best one local muscle fatigue, there was no significant difference for motor manipulation. In motor control, it is essential to coordinate distinct shifting effectors. These effectors include the eyes and hand throughout achieving/pointing moves, and unique systems that include the focal and the postural system for the duration of complete body moves. Altered neck sensory impulse is connected to altered upper limb motor control, due to fatigue and subclinical neck pain (10). Consequent upon the presence of alterations in the neck motor control, subclinical neck pain may reduce an individual's ability to adapt to cervical extensor muscles fatigue. Cervical motor control is affected by chronic neck pain (24,26). The present study suggests that scapular and humeral motor control are also affected (28). Such experimental paradigms exhibit some constraints since the disturbances are simulated and never encountered by

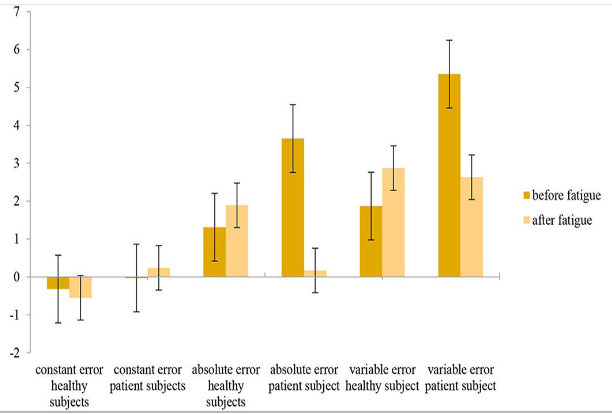

Figure 2. The Error differences Before and After Fatigue

Table 1. Demographic Characteristic of Studied Samples

Variables	Groups	Mean	SD	Range
Age	Interventional group	28.70	6.52	18-39
	Control group	29.10	5.22	18-39
Weight	Interventional group	60.50	8.36	46.0-75.0
	Control group	58.80	8.12	50.5-68
Height	Interventional group	1.64	0.04	1.52-1.71
	Control group	1.61	0.03	1.53-1.69
BMI	Interventional group	22.44	2.74	17.5-27.54
	Control group	23.10	2.98	7.68-28.11

Table 2. Mean Value, Standard Deviation and P Value of the Healthy (N= 23) and fatigue Subjects (N=23)

Variables		Healthy	Fatigue	*P* Value
PPT	Before	3.77 ± 1.19	2.35 ± 0.97	<0.05*
	After	5.67 ± 1.40	3.53± 1.20	
VAS	Before	6.64 ± 4.57	35.60 ± 7.45	<0.05*
	After	4.38 ± 2.36	21.73 ± 10.83	
Side flexion	Before	-40.55 ± 8.09	-41.23 ± 9.77	<0.05*
	After	-47.66 ± 8.04	-46.18 ± 9.50	
Flexion	Before	1.83 ± 0.12	3.10 ± -0.41	>0.05
	After	2.71 ± -0.57	0.96 ± 0.09	
Rotation	Before	1.25 ± 0.21	2.33 ± -0.61	>0.05
	After	3.43 ± 0.50	1.48 ± -1.43	

PPT: pressure pain threshold; VAS: visual analogue scale.

Data presented as mean ± SD.

people's central nervous system (CNS) in their everyday life. It is, however, not true of muscle fatigue which is capable of acting as an unavoidable internal disturbance. This review showed that muscle fatigue is a fascinating experimental tool which stimulates disturbances and provides a better understanding of the principles of motor control (19,28). The effects of fatigue were compensated by changes in the postural and movement strategies. This ensured the precision of pointing at the target and demonstrated that the state of muscle fatigue is taken into account by the CNS; when choosing suitable controllers (10,21). The postural performance remained unchanged and was measured by the center of variables associated with pressure. Adjustments corresponding to muscle fatigue were recorded during posture-movement coordination tasks (which fatigued postural muscles) (28,29). Several sensory receptors are present in the neck muscles. Most of these receptors are present in the deep sections of the sub-occipital muscles. These sub-occipital muscles account for central and reflex links to the visual, vestibular, and postural control systems (29). The literature has an increasing interest in neck pain. This is because such cases provide opportunities for the study of neurophysiologic dysfunction in the absence of the confusing impact of existing pain, which is said to modify sensory processing and motor control (28). Research on neck pain suggests the existence of a relationship between neck pain and the altered motor control of the cervical muscles (i.e., deep neck flexors, extensors, and sternocleidomastoids) (29).

PPT and VAS

The current study's findings confirmed that the fatigue of cause factors significantly improved the variety of movement (ROM) of the thoracolumbar backbone, PPT, and VAS compared to compression at non-cause points. One noteworthy point is that the PPT measures rose in both groups, but the increase was significantly higher in the affected group (28,29). Moreover, critical sensitization (as recommended through the PPTs and different findings of the prevailing take a look at mentioned within the preceding paragraph); is thought to be linked with rearrangement of the somatosensory cortex in chronic ache syndromes, along with variations within the cortical manifestation of painful regions (30,31). Such disturbance in the body map might impact proprioception (32). Primarily based on the present study results, it seems that pain characteristics are not related to joint position error, which is consistent with studies on adult populations (33,34). The argument draws on principal psychophysical records displaying that the variability (i.e., variable error) of the matching errors in an adjustment task reflects the threshold for sensory discrimination (34). Our results suggest that variable error is a more accurate and sensitive indicator for studying joint position sense. The most manageable rationalization of the impact of the neck pain should therefore said to be an alteration of proprioceptive sensitivity (35). Alternatively, pain level did not seem to alter the facts received for repositioning (36). This finding is probably associated with the comparable neck disability rankings located among subgroups irrespective of the VAS pain level, despite the fact that the sample size of a number of subgroups may be questioned (37, 38).

Limitations

The implications of this study should be interpreted with the perception of the take a look at obstacles. The starting position was used to outline zero flexion/extension and consequently was the criterion against which direction-specific range of motion impairments were analyzed. The participants would be asked verbally to sit down in their normal upright position. A more complicated method to ask for this posture could be a bonus. In addition, the head segment was not anchored in an anatomically standardized fashion; it was, therefore, impossible for us to determine the effect of upper cervical posture in the starting position on direction-specific ROM impairments.

Conclusions

The findings of this study provide an indefinite answer to this question: whether the joint position sense error is higher in interventional group with cervical spine lesions due to trauma or non-traumatic neck complaints than in the control group. Neck muscle fatigue had exclusive impacts on neck kinematics for every organization. Repositioning error in neck-side bending repositioning increased significantly following the frontal plane's upper trapezius muscle fatiguing protocol. Neck pain and myofascial trigger point alter cervical kinematics, probably because of altered timing. As hypothesized, fatigue had a greater influence on cervical kinematics in healthy individuals, probably due to the fact that altered neck motor control in interventional group implied that these individuals were not completely able to make up for neck muscle fatigue. Significant changes in PPT were identified after fatigue was applied to the pre-determined myofascial trigger point, but the changes were not significant in the sham control group. Fatigue appears to be an effective therapy for MTrPs in the upper trapezius.

Authors' Contribution

RM wrote the manuscript and designed the study. GRO and MRH developed the original idea and did critical revision of the manuscript for important intellectual content. STM studied concept and design. GRO and ASh contributed.

Conflict of Interests

Authors have no conflict of interest.

Ethical Issues

This study was approved by Ethics committee of Tehran University of Medical Sciences (No. IR.TUMS.VCR.REC 1395.803; 2016/10/22) and registered at Iranian Registry of Clinical Trials (identifier: IRCT2017011426346N2; https://www.irct.ir/trial/21849). All subjects signed an in informed consent from prior to their inclusion.

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