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Original Research Article

INFLUENCE OF GLUTEUS MAXIMUS INHIBITION ON UPPER TRAPEZIUS OVERACTIVITY IN CHRONIC MECHANICAL NECK PAIN WITH RADICULOPATHY

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ABSTRACT

Background: Mechanical neck pain is the most common type of neck pain and commonly to accompany with radiculopathy. Patients of neck pain exhibit greater activation of accessory muscles, (sternocledomastoid, anterior scalene, and upper trapezius muscles) and may also show changed patterns of motor control of other posture muscles as pelvic muscles for reducing activation of painful muscles of neck.

Aim of the study: To determine if there is an association between gluteus maximus inhibition and over activity of upper fibers of trapezius in patients with chronic mechanical neck pain with radiculopathy.

Materials and Methods: Forty female patients participated in this study diagnosed as chronic mechanical neck pain with radiculopathy. Amplitude and onset of muscle activation were assessed by using the surface electromyograghy (EMG) during prone hip extension test.

Results: The results of this study demonstrated that there is no correlation between the amplitude of EMG activity of right and left gluteus maximus and the amplitude of EMG activity of right and left upper trapezius ($P<0.05$).

Conclusion: It can be concluded that the overactivity of the upper trapezius muscle in patients with chronic mechanical neck pain with radiculopathy is not related to the inhibition of the gluteus maximus muscle during prone hip extension test.

KEY WORDS: Mechanical Neck pain, Gluteus Maximus, Upper Trapezius, Surface Electromyography.

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INTRODUCTION

Chronic cervical spine pain is predominantly challenging to treat. The prevalence of cervical pain in the common population has been stated to vary between 30% and 50%, in addition to prevalence rate for men less than women. Many of these cases resolve with time and require minimal intervention. Cervical pain has high recurrence rate, and about one-third of people will suffer from chronic neck pain (defined as pain that persists longer than 6 months) and those patients have the incidence more to complain of radiculopathy. Neck pain develops significant disability and reduction in quality of life [1]. According to the International Association for the Study of Pain (IASP), neck pain is pain supposed as anywhere in the dorsal aspect of the cervical spine, defining it further as pain that is "perceived as arising from anywhere within the region bounded superiorly by the superior nuchal line, inferiorly by an imaginary transverse line through the tip of the first thoracic spinous process, and laterally by sagittal planes tangential to the lateral borders of the neck" stated by Danielle et al. [2]. An imaginary transverse plane divided neck pain equally into upper and lower cervical pain. The IASP describes radicular pain as appearing in the trunk wall or a limb, produced either by nociceptive afferent fibers ectopic activation in a spinal nerve or its roots or by other neuropathic mechanisms, and may be recurrent, episodic, or sudden [2].

Most patients with neck pain usually lack an identifiable pathoanatomic cause for the problem so this condition is diagnosed as mechanical neck disorders [3]. Chronic type of mechanical neck pain is commonly to accompany with radiculopathy. It is one of the most common and painful musculoskeletal conditions [4]. Mechanical neck pain (MNP) is mainly 'diagnosed' on the basis of clinical grounds, provided there are no features to suggest a specific or more serious condition [5].

Approximately 30% of people with MNP have restrictions in the activities of daily living. Young active adults are more incidences to have MNP. Neck pain increases with age up to 40 to 60 years [6].

Bad posture is a common cause of mechanical neck pain and also is a common secondary defense mechanism of the body to decrease pain in neck muscles. Over activation of the upper trapezius (UT) muscle in response to repetitive upper limb movements is common in chronic MNP (CMNP) [7]. This over activation of UT may be related to the inhibition of the gluteus maximus (GM) muscle during gait. Functional movement is never isolated because it is produced by several muscles acting as prime movers, synergists, or stabilizers that coordinate together to produce the movement. These muscles act in a sequence to produce movement pattern. Thus muscle onset and timing are important for assessment [8].

Delay in the activation of the GM muscle in hip extension movement pattern during gait leads to earlier activation of hamstring and erector spinae muscles to stabilize the lumbar spine [9]. This inappropriate activation of the gluteus maximus in gait is thought to be a cause of low back pain (LBP), resulting in a deficiency in the shock absorption mechanism at the sacroiliac joint [10, 11]. **Page et al.** [8] suggested that more inactivation and or inhibition of the GM muscle lead to abnormal sequence of muscle contraction in hip extension movement pattern during gait. Muscles that are not related to the pattern of hip extension may be activated to counterbalance for GM delay. These compensating muscles are the UT muscle which could be the first muscle to activate then the latissmus dorsi, immediately followed by the hamstrings and thoracolumbar muscles [12]. These over activation inthe neck muscles and UT muscle might create cervical dysfunction and pain so determining the cause of this over activation is the key for management of CMNP patients with radiculopathy.

The amplitude and timing of muscle activation are usually calculated to assess muscular activation patterns by using electromyography (EMG) in musculoskeletal disorders [13]. The majority of previous studies have evaluated the timing of muscle activity through prone hip extension (PHE) in LBP patients to identify the order in which the muscles are activated during this motor pattern [11,12, 13]. A common and widely accepted test for measuring the muscular activation pattern in the lumbo-pelvic area is PHE [12].

The importance of PHE is that the muscle activity pattern during this movement has been theorizedto simulate those used during functional movement patterns such as gait. It is thought that changesin this pattern can decrease the stability of lumbo-pelvic region during walking [14]. The sequence of muscle contraction in PHE consisting of initial motion, usually in the hamstrings, followed by the gluteus maximus, contralateral lumbar spinal erectors, ipsilateral lumbar erectors, contralateral thoracolumbar spinal erectors, and ipsilateral thoracolumbar spinal erectors [8]. As a result from these previous studies; the purpose of this current study is to investigate if there is any correlation between inhibition of gluteus maximus muscle and over activation of upper fibers of trapezius muscle in CMNP patients with radiculopathy.

MATERIALS AND METHODS

This study was conducted in the Motion analysis laboratory of the Faculty of Physical Therapy, Cairo University. To investigate if there is any correlation between inhibition of gluteus maximus muscle and over activation of upper fibers of trapezius muscle in CMNP patients with radiculopathy.

Subjects: Forty female patients diagnosed as chronic mechanical neck pain with radiculopathy were selected randomized from the outpatient clinic of the Faculty of physical therapy, Cairo University. Each patient was informed of the protocol for this study and was allowed to ask questions or exit the study at any time and signed the informed consent form.

Patients were included if they had chronic mechanical neck pain with radiculopathy for more than three months. The age ranged from 20 to 30 years old. Body mass index (BMI) was less than 30 kg/m^{2,} for all patients participated in this study as the amplitude, time and frequency domain properties of the surface electromyography (SEMG) signal are affected by the thickness of overlying skin and adipose tissue. The more superficial muscle and the lesser amount of subcutaneous adipose, the greater the SEMG amplitude [15]. Patients were excluded if they had previous surgery or fracture of the cervical spine, neoplastic conditions, vascular compromise and myelopathy [1].

Instrumentations for assessment:

Surface Electromyography: It is commonly used to assess muscular activation patterns in musculoskeletal disorders by measuring the timing and amplitude of muscle activation. It is considered as an objective tool to assess muscle activity [13, 16]. Myomonitor Wireless EMG system **(DE 2.3 EMG sensor, Delsys, Inc., USA),** with an inter-electrode distance of 1 cm, was used for assessing the myoelectric activities of the UT and GM muscles in this study. It is an eight channels, dual-mode portable EMG and physiological signal data acquisition system. The portable design allows experiments to be conducted in environments that are not accessible with conventional systems.

Height and weight scale: A universal height and weight scale was used to determine height and weight of the participant to calculate body mass index (BMI= Kg/m^2). Identification of body mass index by using this equation [17].

Assessment procedures: Demographic data were collected from all patients to document age, weight, height, BMI as well as other clinically relevant information. Both legs were investigated. The muscle activity of UT and GM during PHE was measured by surface EMG instrument.

Patients were asked to lie prone with their arms at their side and head was in mid line. The skin was shaved, rubbed and cleaned with alcohol. To record muscle activity, Surface electrodes (Ag/AgCl) were placed parallel to the muscle fibers [18]. Electrodes placement to collect EMG signals were as follow: for UT at the midpoint of a line running between the C7 spinous process and the lateral tip of the acromion [19] and for the GM, at the mid point of a line running from S2 to the greater trochanter [20]. The reference electrode was placed over the right ulnar styloid process.

The first leg to be assessed was chosen by cards and the patient chose the card randomly, the word written in the card was (right side first or lift side first). The positions of limb and foot were manually and verbally supervised throughout the performance to ensure that the subject maintained neutral hip rotation, full knee extension, and neutral ankle flexion, because outward rotation of the hip joint and ankle dorsiflexion especially facilitated the glutei [20].

Before testing, the participants were familiarized with the standard position and movement. All subjects were asked to lift the chosen leg off the bed to 10 degrees whilst keeping the knee straight, as soon as they heard the command "lift". This was repeated 3 times for each leg with a 1-min rest period between each trial. The mean of the three trials for each exercise was used for analysis. Some trials were excluded because of noise in recorded EMG signals and because of improper recording [21].

After the prone hip extension trials were completed, we collected the EMG activity during maximal voluntary isometric contraction (MVIC) trials in which maximal manual resistance was applied to each muscle group. For these MVIC tests, standard manual muscle testing techniques was used. Specifically, the gluteus maximus muscle was tested with the hip extended, the knee flexed to at least 90, and resistance applied to the distal aspect of the posterior portion of the thigh. The upper trapezius was tested from setting position and resistance applied above the shoulder with a command to shrug the shoulder girdle. Participants performed a three repetition and held contractions for at least 1 second and the mean of the three repetitions was used to normalize muscle activity [13].

Data Analysis

1. Raw EMG was amplified (bandwidth = 20 - 450 Hz, CMRR>80 db at 60 Hz, input impedance = 10 GÙ) and collected with a sampling frequency of 1000 Hz using a 16-bit A/D card with a ± 2.5 V rang.

2. The root-mean-square (RMS) envelope of the EMG signal was calculated using a moving window with a window length of 0.125 s and window overlap of 0.0625 s.

Statistical analysis: All statistical measures were performed through the Statistical Package for Social Science (SPSS) version 18 for windows. As a prerequisite for parametric assumption, data was screened for normality and homogeneity of variance assumptions. Normality assumption was assessed using the tests of normality in addition to assessing for the presence of extreme scores, and skewness and kurtosis.

Regarding the root mean square (RMS) of upper trapezius, data exploration revealed that the skewness, and kurtosis exceeded the recommended values and the tests of normality were significant ($p<0.05$ for both right and left sides) indicating that the normality assumption was violated. In addition, the tests of homogeneity of variance were significant ($p<0.05$for both right and left sides), indicating that the homogeneity of variance was violated. Thus, the researchers conducted non parametric analysis. Wilcoxon Signed Rank tests were used to compare between the right and left sides for the RMS of upper trapezius.

Concerning RMS of gluteus maximus, data were screened for normality assumption, homogeneity of variance, and presence of extreme scores. Descriptive analysis using histograms with the normal distribution curve showed that the data were normally distributed and not violates the parametric assumption for each of the right and left sides. Additionally, testing for the homogeneity of covariance revealed that there was no significant difference with p values of > 0.05. The box and whiskers plots of each of the tested variables showed that there were no outliers or extreme score. All these findings allowed the researchers to conduct parametric analysis. Paired t test was conducted to compare RMS of gluteus maximus between right and left sides. Association between gluteus maximus muscle inhibition and over activity of upper trapezius muscle have been done by using Pearson product-moment correlation coefficient in order to determine if there is any significant relation. The level of significance was ($P < 0.05$).

RESULTS

The median of RMS of upper trapezius in the right and left sides were 12.58 and 14.05 respectively. "Wilcoxon Signed Rank tests" revealed that there was no significant difference between the right and left sides in RMS of upper trapezius ($Z = -0.121$, and $P = 0.904$). While, the mean ± SD values of RMS of gluteus maximus in the "right" and "left" sides were 52.56±20.02 and 47.51±18.89 respectively. "Paired t test" revealed that there was no significant difference of RMS of gluteus maximus in both sides (t-value= 1.449, P-value =0.155).

Pearson product moment correlation coefficient was used to determine the correlations between the right upper trapezius and right gluteus maximus and between left upper trapezius and left gluteus maximus. The initial alpha level for the correlation analysis was set at 0.05.It revealed that there was no significant correlation between right upper trapezius and right gluteus maximus (r = -0.01, p= 0.953) as shown in figure (1). As well as, it revealed that there was no significant correlation between left upper trapezius and left gluteus maximus (r = 0.256, p = 0.11) as shown in figure (2).

Fig. 1: Scatter plot for the bivariate correlation between right upper trapezius and right gluteus maximus.

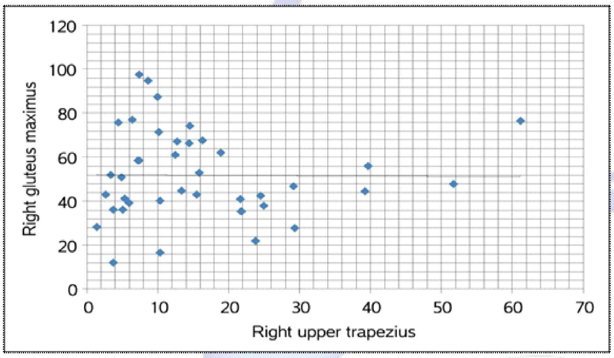
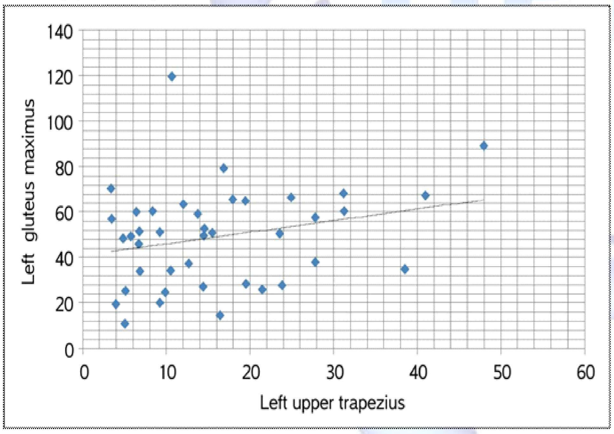


Fig. 2: Scatter plot for the bivariate correlation between left upper trapezius and left gluteus maximus.



DISCUSSION

The incidence and recurrence rate of CMNP with radiculopathy are high, so its prevention and treatment are important [22]. The first step toward prevention and appropriate treatment is identification of possible causes associated with CMNP and their interaction. Over activation of UT muscle and other neck muscles are common to be found in CMNP patients with radiculopathy [7, 23]. The purpose of this study was to investigate if the inhibition of gluteus maximus muscle is cause of over activation of upper fibers of trapezius muscle in CMNP patients with radiculopathy. Results of the current study showed that, there was no significant correlation between gluteus maximus inhibition and over activity of upper trapezius in CMNP with radiculopathy. Statistical analysis of the current study revealed that there was no significant difference between the right and left sides in RMS of upper trapezius, these results could be interpreted to physiological and anatomical asymmetries at different levels of the central nervous system controlling the upper extremity that had been established. Handedness-related asymmetries exist in the motor cortex. In addition to asymmetries in the nervous system, side differences exist in the muscles. Long-term preferential use of muscles of the dominant side of the body may result in changes of muscle fiber composition with a higher prevalence of slow twitch type I fibers. The shift towards slow twitch fibers is associated with changes in motor unit control properties, which results in reduced firing rates of motor units on the dominant side [24]. No significant difference in EMG amplitude between RT and LT sides of upper trapizius in this current study might also attributed to overactivity of upper trapezius and levator scapula at one side can cause contralateral cervical rotation; in order to keep the head level and in a fixed position, the contralateral upper trapezius will become activated, so both upper trapezii will eventually become tight. This is agreed also with [25].

The results of this study also revealed that there was no significant difference in the EMG amplitude of gluteus maximus between RT and left sides. As mentioned previously, physiologically there is difference in EMG amplitude between dominant and non dominant sides. In pathological cases this activation pattern is changed so this might explain why there was no difference between RT and left sides of gluteus maximus in this current study [26].

According to **Van Wingerden et al.** [27], GM has an important role in sacroiliac joint (SIJ) stability because of its perpendicular fibers to the SIJ. Therefore, any pain and pelvic instability can lead to increased muscle activity especially in tasks that are required hip extension to enhance the SIJ stability. However, in this study we did not differentiate the SIJ pain. Thus in this current study the cause of no difference in EMG amplitude of gluteus maximus between RT and LT sides might due to LBP or SIJ pain on the dominant side or over activity of the dominant side that leads to increase EMG activity at that side to be equal or more than the non dominant.

Statistical analysis of our study revealed also that there was no significant correlation between the amplitude of the RT and LT gluteus maximus and RT and LT upper trapezius respectively in CMNP patients with radiculopathy. This might attributed to the inhibition in the gluteus maximus was in the first or second degree inhibition so that it might lead to abnormal sequences I and II of hip extension movement pattern. In these abnormal sequences the most common sign of a faulty movement pattern is over activation of the hamstrings and erector spinae and delayed or absent contraction of the gluteus maximus**.** The poorest pattern occurs when the thoracolumbar extensors or even the shoulder muscles initiate the movement due to delayed or absent the gluteus maximus contribution [12]**.** It is suggested that the young age of our participants was an important factor, as increased inhibition severity of gluteus maximus will lead to activation of the upper trapezius and abnormal sequence III that occurs with age progression. **Arab et al.** [21] found that in some cases an inhibited muscle may be working harder than normal to produce the required force for a particular task, thus, the GM activation percent of the MVIC is increased to accomplish hip extension.

In our study observation of the onset time of muscle activation revealed that there was (17.5%) in the RT side and (57.5%) in the left side in which the upper trapezius preceded the GM during PHE test. Also, there was (47.5%) in the RT side and (25%) in the left side in which the upper trapezius was delayed during PHE test. Also there was (2.5%) in the RT side and (7.5%) in the left side in which the upper trapezius and the GM had the same onset of activation during PHE test and (32.5%) in the RT side and (10%) in the left side in which the upper trapezius was not activated during PHE test. These results might be related to the degrees of inhibition of the GM, as in the first degree or second degree inhibition the upper trapezius might be activated during PHE but after the gluteus maximus and in third degree inhibition the upper trapezius might be activated before the gluteus maxims. For more explanation of this point, more future studies on PHE with examination of the activation of all muscles involved in the pattern in patients with CMNP with radiculopathy are needed.

There is no standard accepted method of determining the onset of muscle activity from an EMG sample. The previous studies which had been published pertaining to the motor patterns used during PHE used techniques varying from a visual evaluation of the signal by the researcher(s) to the use of mathematical algorithms calculating the onset as the sample at which the signal exceeds a certain percentage of the peak EMG activity or a certain number of standard deviations above a baseline average [11, 16, 28]. Thus if this study is repeated but with other methods of calculating amplitude and onset time there may be different results, so further research is recommended with another methodology and with a control group of normal participants not complaining of neck pain. This study has some limitation. First, the speed of the movements was not controlled in the present study. It is well known that the magnitude of the EMG signal can be directly influenced by several factors, such as speed, acceleration, range of movement, load and repetitions. However, although the speed was not controlled, the participants were instructed to perform the movements at their natural speed in order to reproduce a situation similar to that employed in clinical practice. Second, inclusion criteria should have pain dominant side because the dominance affects results of EMG amplitude of both UT and GM and so the correlation of our study.

CONCLUSION

It can be concluded that there was no correlation between the amplitude of the gluteus maximus muscle and the amplitude of the upper trapezius in chronic mechanical neck pain patients with radiculopathy during PHE test. So the over activity of upper trapezius is not related with the inhibition of the gluteus maximus in CMNP patients with radiculopathy but there were an observation regarding to onset of muscle activation that need more studies to be explained.

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Conflicts of interest: None

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