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# Neck Muscles Sense of Force in Healthy Individuals and Subjects with Trigger Points of the Upper Trapezius Muscle

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**SUMMARY**

**Introduction.** Trigger points can be the source of radiating pain and may interfere with normal muscle function. The aim of this study is to investigate the neck muscle's sense of force in subjects with trigger points of the upper trapezius muscle compared with healthy subjects.

**Materials and methods.** In a cross-sectional analytical study, in 40 young subjects with hidden trigger points of the upper trapezius muscle and 40 healthy young subjects, constant, absolute and variable error of sense of force of cervical muscles, range of motion of neck and pressure pain threshold of upper trapezius muscles in both groups were measured.

**Results.** The absolute and variable error of sense of force in the extensor and lateral flexor muscles of the neck were significantly different between two groups, and the subjects with hidden trigger points had higher errors. The pain threshold of both sides in subjects with hidden trigger points was significantly lower than healthy subjects. The range of motion wasn't significantly different between the two groups.

**Discussion and conclusions.** This study showed that the sense of force error was higher in subjects with trigger points. Also, the pressure pain threshold in subjects with trigger points were lower than healthy subjects. As a result, In the evaluation of neck pain patients, it is important to pay attention to sense of force error.

**KEY WORDS**

*Force sense error; head and neck; proprioception; trigger points; upper trapezius muscle.*

## INTRODUCTION

Trigger points (TPs) (1) are tight, palpable, distinct and localized knots in skeletal muscles that cause refferal pain (1, 2). Different types of trigger points (TPs) include: cutaneous, fascial, ligamentous, periosteal, and myofascial, the most common of which is "myofascial" (1). Myofascial trigger point (MTrP) is a hypersensitive spot in skeletal muscles or fascia that it can be with taut band or not (3). MTrPs mostly occur in muscles that play a key role in controlling posture, such as levator scapula, upper trapezius (UT), sternocleidomastoid, scalene, erector spinae, quadratus lumborum and gluteal muscles (4). This disorder is more common in the upper quarter of the body, especially the UT muscle (5). Bad postures may cause TPs in upper quarter of the body muscles (6). The upper part of the trapezius muscle is one of the important postural and stabilizing muscles in head and

neck area. Myofascial pain related to the presence of chronic TPs of the UT muscle can causes pain and disability in the neck region (4). The occurrence of TPs have prevalence ranging from 30% to 93%, especially in people who remain in improper and prolonged posture of head and neck (1, 7, 8). It is suggested that the occurrence of TPs can cause functional neck disorders, tension headaches, mechanical neck pain, reduced fascial elasticity and restircted range of motion (ROM) (9). Also, it may have harmful effects on social life and activity of daily living. Proprioception plays an important role in regulating the overall posture and balance of the body and consciously sensing movement and force (10). Proprioceptors include free nerve endings and mechanoreceptors in the skin, fascia, muscles, tendons, joint capsule and ligaments (11). Proprioception has the components for detecting the position and movement of body segments (called sense of position and movment respectively) and also the force or tension of muscles (called sense of force) (12-14).
Various factors such as neck pain, fatigue and inflammation may reduce proprioceptive input and imapir proprioception (10, 15-18). The presence of TPs can cause all the mentioned symptoms (11, 19, 20). Geist *et al*. reported that releasing trigger points of ankle muscles could improve proprioception in patients with lateral ankle sprain (21). The occurrence of inflammation in the muscle causes hypoxia, pain and fatigue, and these complications are directly related to the inefficiency of the muscle function and loss of proprioception (12, 22). Weerakkody *et al*. reported that muscle pain cause inhibitory effect on spinal motor neurons as a result, it may increase the force sense error (23).
TPs can cause pain in different mechanisms. They may cause long-term contarction and local spasm on sarcomeres while there may lead hypoxia and incresases pain sensitivity. All these events eventually create a faulty cycle of spasm-pain (1, 13, 24). Researches stated that existence of TPs causes disturbance in the range of motion and affect the kinematics of cervical spine which inturn can disturb proprioception (4, 25).
Considering the role of muscle receptors in the proprioception and the high density of these receptors in the muscles of the cervical area, neck proprioception plays a key role in controlling posture and movement. So it seems important to pay attention to the proprioception of neck and its evaluation and treatment in disorders of this area (11). Only one study was available to the researchers that examined the proprioception of subjects with head and neck TPs who suggested that patients with TPs have more position sense error in neck region (11).
On the other hand Dochetry *et al.*, Kim *et al.* and Niespodziński *et al.* did not observe a relationship between the sense of position and the sense of force in subjects with chronic ankle instability (26-28). So a disturbance in the sense of position will not necessarily lead to a disturbance in the sense of force (28). However researchers stated that head and neck TPs may disturb position sense of neck area (11), it is important to examine the sense of force error of neck region seperately. No published study has investigated the sense of force of neck muscles in people with trapezius muscle HTPs. Therefore, the aim of this study is to compare the sense of force of neck muscles between people with HTPs and healthy people. If a disturbance in the sense of force is observed in these people, while showing the necessity of paying attention to this aspect of proprioception in the evaluation of these people, perhaps future studies can improve the proprioception of this area by treating muscle TPs to decrease the risk of neck disorders.

## MATERIALS AND METHODS

In this cross section analytical study, 40 subjects with HTPs of the UT muscle with an average age of 24.1 and 40 healthy subjects with an average age of 24.2, were recruited using a simple convenient nonprobability sampling method in Sardasht city. The inclusion criteria of subjects with TPs include: 1) age range between 18 and 30 years; 2) Inactive TPs in the UT muscle were diagnosed based on the examiner's clinical examination and having at least three of the following: a) Palpable taut bands in the muscle; b) Sensitive points in the form of nodules on taut bands; c) Referral pain after pressure or traction; d) Local contractile response following pressure; 3) Having pain equal to or greater than 3 on the visual analogue scale (VAS) by applying a force with an intensity of 2.25 kg/cm by the algometer device. Healthy subjects were recruited to study while they were at same age range and they must be free of TPs and pain by applying a force of 2.25 kg/cm (using an algometer) in the UT muscle. The subjects with active TPs in UT and other neck muscles, experience of surgery in head and neck, and head and neck trauma or neck pain in last six months were excluded.
The tools required for data collection were: 1) force sense measurement tool (dynamometer), 2) visual analogue scale for pain assessment, 3) universal goniometer and 4) pressure algometer.

### Ethics

The Ethics Committee of Shahid Beheshti University of Medical Sciences approved this research by the following protocol number (SBMU.RETECH. REC.1397.1376 – Date of approval: March 17, 2019). Individuals signed the written consent form to participate in the research.

### Test method

After recruiting the subjects based on inclusion and exclusion criteria, they signed an informed consent form before participating in the test. The demographic information of the subject also was recorded. For this purpose, the height and weight of the samples were measured using a scale and tape measure attached to the wall, and the body mass index (BMI) was calculated. The trigger points in upper trapezius muscles were inspected while subject sat on a chair whose height was proportional to the examiner's height so that the subject's head was placed in the mid line of the body, hands were on the thighs and the soles of the feet were completely in contact with the ground. The examiner looked for muscle taut bands from the occiput prominence to the acromion appendage with the thumb flat palpation (29-31). This method has good inter-examiner reliability for detecting TPs (24, 32). In the next step, the sensitive points were marked with a marker, and a force equal to 2.5 $kg/cm^2$ was applied to these points through a pressure algometer (made in Taiwan, model 5020) and the subject reported the perceived pain by  number between zero and ten on visual analogue scale (VAS). If the reported number was more than 3, the subject met the criteria for entering the study as patient group and was prepared to perform the test.

In the next step, the subject sat on the chair in a relaxed position so that the back spine was protected by the back of the chair. Both hip joints were placed in 90-degree flexion. In order to prevent the feet from pressing on the ground during the contraction of the neck muscles, a tripod was used and it was placed under the rearfoot and forefoot was hang down. The knees were flexed at 30 degrees and the hands of subject were placed on the thighs during the test. In order to place the head and neck in neutral position, the sternal notch, chin and tip of the nose were placed in one line and parallel to the vertical axis of the body, and the line connecting the base of the nose and the occiput was placed at horizontal level. The examiner advised the subjects to relax their trunk and upper and lower limbs and try to apply force to the side and back of their head by pressing the head and neck only.

In order to evaluate the force sense error, a dynamometer with H3-C3 load cell by Zemic company from Netherlands was used, the validity  and reliability of which was checked and confirmed in the research center of the rehabilitation faculty. The dynamometer was installed on the wall and its monitor was placed on a stand in front of the subjects. To introduce subjects with the test steps, before the test, a submaximal isometric contraction was taken from the specified muscles.Then  the maximum voluntary isometric contraction (MVIC) was determined in the extensor and lateral flexor muscles of the head and neck. To evalualuate the head and neck extensor muscles, in sitting position the plate of dynamometer was placed behind the subject's head and its center was placed in front of the occiput bone and to evaluate the lateral flexor muscles of the head and neck, the subject was placed in a sitting position and laterally next to the plate installed on the wall. This plate was placed on the side of the head above the upper edge of the ear in front of the temporal bone.

The subjects were asked to press the dynamometer plate with maximum force 3 times with a one-minute interval, and during the effort, the same verbal feedback was given to encourage them. The individual's MVIC was recorded in kilograms during each of the three attempts and converted to Newtons. The maximum recorded value used as the MVIC value of the muscle. Then the 30% of this value was used as the target force. The target force is the force that the person must reproduce it without looking at the monitor of the dynamometer. The subject was asked to presse the dynamometer with the isometric contraction of the extensor and right and left lateral flexor muscle group to reach the target force value which is 30% of the MVIC of the defined muscle group and maintained this position for 30 seconds to remember the force. Then, while the monitor was moving away from the subject's sight, the subject tried to reproduce the target force by relying on the proprioception. This was repeated three times with an interval of 30 seconds between each trial, and the reproduced force was recorded each time. The difference between the target force and the reproduced force shows the amount of force sense error, and the average error of three repetitions was recorded as the force sense error of specified muscle group. The force sense error was calculated using three scales including: Absolute Error (AE) is defined as absoulute difference between the target force and the percieved or reproduced force, Constant Error (CE) (the amount of error including the direction of the difference between the two values) and Variable Error (VE) represents the variability of the errors between trials (calculated by standard deviation of the error in three trials) and indicates the cosistencey of proprioceptive performance (33).

The order of force sense error evaluation of muscle groups was randomly selected.

The range of right and left lateral flexion and extension of neck movements was evaluated by universal goniometer made by MSD company in Belgium in all of the subjects. Universal goniometer has been reported to have good reliability for measuring neck range of motion (ICC 0.73-0.89) (34, 35). To evaluate the active head and neck range of motion the subject sat on the chair with the foot on the floor and hands on the thighs. For neck extension, the center of the goniometer was placed on the soft part of the ear, and one of its arms was placed perpendicular to the ground and the other arm was placed on the base of the nose. The extension movement was performed by the subject. The result was recorded on the goniometer. To evaluate the neck left and right lateral flexion, the center of the goniometer was placed on the C7 spinous process, one of its arms perpendicular to the ground and the other parallel to the posterior and middle surface of the skull. The subject moved the head and neck twice, and the second time the obtained number was recorded on the goniometer (36).

### Pain measurement using visual analogue scale

On a horizontal bar marked from 0 to 10, the number zero indicates the state without pain and the number 10 indicates the maximum possible pain (37). Previous studies have investigated the reliability and validity of this tool in measuring pain and have obtained acceptable values (38). The tape of the visual pain scale is 100 mm long, but in most cases, for ease of use, it is divided between the numbers zero to ten so that patients can use it more easily.

### Algometry

Pressure algometer was used to evaluate pressure pain threshold in both groups. Algometer is a tool for measuring pain sensitivity and evaluating pain sensation. The device used in this study has measurement accuracy of 0.01 kg/cm$^2$. A metal piece with a diameter of 1 cm$^2$ is connected to the algometer and it records momentary force changes. The reliability of this tool in evaluating pain pressure treshold has been reported very well (ICC 0.75-0.89) (39, 40). In each subject, 3 points of the UT muscle were tested bilaterally. In order to check the pressure pain threshold, a gradually increasing force was applied in the sitting position until the pressure sensation changed to pain sensation and the obtained value was recorded. To check the intensity of pain, pressure pain equivalent to 2.5 kg/cm$^2$ was applied to the marked points and the pain intensity felt by the samples was reported on the visual analogue scale (VAS) (41). The tests were conducted by an examiner at an interval of 30 seconds. After evaluating all the variables in two groups of subjects with HTPs and healthy subjects, the data was analysed by SPSS (version 20) software. The Kolmogorov-Smirnov (K-S) test was used to check the normality of the distribution of variables, and according to the normal distribution of the variables, the parametric test of comparison of means (t-test for two independent groups) was used to compare the variables between two groups.

## RESULTS

40 healthy women and 40 women with HTPs were evaluated. As shown in **table I**, there were no significant differences in demographic variables between the two groups.

**Table II** shows the force sense error values of different muscle groups in the healthy subjects group and subjects with HTPs group.

Based on the results of **table II**, no significant difference was determined between the HTPs and healthy groups in terms of the amount of constant error of head and neck extensor and right and left lateral flexor muscles, but in terms of absolute error and variable error of head and neck extensor and right and left lateral flexor muscles, the average scores of the subjects with HTPs group were significantly higher than the subjects in healthy group. The results of the comparison of the two groups in terms of pressure pain threshold indicate that there is a significant difference between the two groups in terms of the average pressure pain threshold on both the right and left UT muscle and the mean pressure pain threshold of the subjects with HTPs group was lower compared to the healthy group.

Based on **table III**, there is no significant difference between the two groups of HTPs and healthy group in extension and right and left lateral flexion range of motion.

**Table I.** Demographic characteristics of the samples examined in this study and checking the homogeneity of the two groups (n = 80).

| Variables | Group | Number | Mean | SD | Min. score | Max. score | P-value |
|---|---|---|---|---|---|---|---|
| Weight | With HTPs | 40 | 64.73 | 6.96 | 52 | 76 | 0.95 |
| | Healthy | 40 | 64.63 | 7.79 | 52 | 78 | |
| Height | With HTPs | 40 | 164.07 | 6.19 | 155 | 178 | 0.41 |
| | Healthy | 40 | 163.05 | 4.95 | 156 | 175 | |
| Age | With HTPs | 40 | 24.15 | 3.59 | 18 | 30 | 0.88 |
| | Healthy | 40 | 24.27 | 3.95 | 18 | 30 | |
| BMI | With HTPs | 40 | 24.07 | 2.55 | 19.13 | 30.02 | 0.60 |
| | Healthy | 40 | 24.43 | 3.71 | 17.99 | 31.24 | |

**Table II.** Comparison of force sense error values of different muscle groups and pressure pain threshold in subjects and controls.

| Variables | Groups | Mean (n) | SD | P-value |
|---|---|---|---|---|
| Extension CE | With HTPS n = 40 | 4.12 | 183.2 | 0.98 |
| | Healthy n = 40 | 3.66 | 60.3 | |
| Extension AE | With HTPS | 170.1 | 137.7 | **0.001** |
| | Healthy | 62.1 | 37.2 | |
| Extension VE | With HTPS | 168.3 | 112.1 | **0.001** |
| | Healthy | 56.1 | 34.7 | |
| Rt. side flexion CE | With HTPS | -5.12 | 142.5 | 0.32 |
| | Healthy | 18.33 | 60 | |
| Rt. side flexion AE | With HTPS | 148.3 | 79.7 | **0.0001** |
| | Healthy | 61.5 | 25.7 | |
| Rt. side flexion VE | With HTPS | 127.4 | 74.6 | **0.0001** |
| | Healthy | 40.6 | 15.5 | |
| Lt. side flexion CE | With HTPS | 42.33 | 69.1 | 0.06 |
| | Healthy | 18.62 | 37.6 | |
| Lt. side flexion AE | With HTPS | 97.66 | 51.3 | **0.0001** |
| | Healthy | 61.54 | 21.8 | |
| Lt. side flexion VE | With HTPS | 90.39 | 66.7 | **0.035** |
| | Healthy | 65.91 | 27.4 | |
| Rt. pressure pain threshold | With HTPS | 4272.3 | 1024.4 | **0.0001** |
| | Healthy | 6584.4 | 1136.2 | |
| Lt. pressure pain threshold | With HTPS | 4772.1 | 992.9 | **0.0001** |
| | Healthy | 6581.5 | 1148.1 | |

CE: constant error; AE: absolute error; VE: variable error; SD: standard deviation; Rt: right; Lt: left.

**Table III.** Comparison of the range of motion of extension and lateral flexion to the right and left between the two groups.

| Variables | Groups | Number | Mean (degree) | SD | St. error | P-value |
|---|---|---|---|---|---|---|
| Ext. ROM | With HTPs | 40 | 66.8 | 4.7 | 0.74 | 0.69 |
| | Healthy | 40 | 67.2 | 5.3 | 0.83 | |
| Rt. Lat. Flexion ROM | With HTPs | 40 | 44.7 | 3.5 | 0.55 | 0.97 |
| | Healthy | 40 | 44.8 | 4.1 | 0.64 | |
| Lt. lat. Flexion ROM | With HTPs | 40 | 43.3 | 3.5 | 0.55 | 0.08 |
| | Healthy | 40 | 44.9 | 4.2 | 0.67 | |

Ext: extension; Rt: right; St: standard; Lat: lateral; Lt: left.

## DISCUSSION

The results obtained from the analysis of statistical data showed that in the subjects with HTPs in the UT muscle, the sense of force is disturbed in all three movements of extension, right and left lateral flexion, and the absolute and variable error of the sense of force in all muscle groups of subjects with HTPs was more than healthy subjects.

Only one study was available to the researchers that investigated the cervical proprioception in subjects with TPs in head and neck muscles and reported that they have more position sense error in neck region (11). But in their study, only the sense of the position was investigated and the sense of force was not evaluated, while studies have shown that the sense of position and the sense of force evaluate the different aspects of proprioception and may not be related to each other (26-28). There was no available study to the researches that investigated the sense of force in these subjects, with which the results of the present study can be compared.

Researchers reported that the presence of TPs may increase pain and inflammation (42-45). Also, Proske *et al*. and Weerakkody *et al*. observed a relationship between pain and increased error of sense of force (13, 23). Geist *et al.* demonstrated that releasing TPs could improve proprioception in patients with lateral ankle sprain (21). Also, the disorder in the sense of force in different muscle groups of the neck can be justified in these subjects who have pain and inflammation, but this aspect of proprioception has not been previously investigated in these subjects**.** It is possible that the disorder in the sense of force in the cervical extensor and lateral flexor muscles cause that these muscles cannot apply the right amount of muscle force in neck movements which may cause damage in these muscle groups. So it is necessary to pay attention to the measurement of the sense of force in the evaluation and treatment of subjects with HTPs, and appropriate methods should be used to train and improve the sense of force in these subjects.

The results of this study did not show a significant difference between the range of motion of extension and right and left lateral flexion in the healthy subjects and subjects with HTPs group, which is different from the results of previous studies in this issue (31, 44, 46), which is probably due to the different methods and tools used in these studies. The results of this study also showed that the average pressure pain threshold in the group with HTPs is lower than the group without HTPs, which confirms the findings of the previous studies (13, 15, 23, 46). Shah *et al*. concluded that the presence of TPs in the UT muscles caused an increase in inflammatory substances and the occurrence of pain, and as a result, the pressure pain threshold in the mentioned group was lower than in the healthy group (42).

## CONCLUSIONS

Based on the the results of this study, existence of HTPs in UT muscle could disturb the sense of force of extensor and lateral flexor muscles in cervical region. Due to the importance of this sense in the accurate application of muscle force, this defect in the sense of force may cause a disturbance in the precise application of force, which can lead to a defect in controlling the movement of the head and neck area. According to the results of this study, the assessment of the sense of force should be included in the clinical examinations of people with trigger points, and if a defect in the sense of force is observed, appropriate exercises should be prescribed to recover this sense to a normal state. Future studies should focus on investigating the effectiveness of different exercises in reducing force sense error and its effect on improving the symptoms of people with trigger points.


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None.


## DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

## CONTRIBUTIONS

MKZ, MS: conceptualization. MKZ, MS, KKK: methodology. MS, DSK: investigation. AAB, MS: data analysis. MS, DSK: writing - original draft. MKZ, DSK, KKK: writing - review and editing.


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## CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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