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Comparison of upper trapezius muscle stiffness between female assembly workers with and without myofascial trigger points

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Abstract

Background: Muscle stiffness in the upper trapezius (UT) muscle is a significant parameter for evaluating myofascial trigger points (MTrPs). Because the measuring position influences UT muscle stiffness, investigating UT muscle stiffness in different working postures would be useful for evaluating and planning effective interventions for MTrPs.

Objective: To identify differences in UT muscle stiffness measured in the resting and working postures among female assembly workers, both with and without MTrPs.

Methods: Eighteen female workers with right (Rt) side UT MTrPs and 18 workers without MTrPs participated in this study. We measured UT muscle stiffness on both sides in resting and working postures using MyotonPRO. A multivariate analysis of variance was used to investigate the differences in UT muscle stiffness.

Results: In the working posture, the MTrPs group exhibited a significantly higher UT muscle stiffness on the Rt side, measuring 386.22 N/m, compared to the non-MTrPs group (335.22 N/m, $p = 0.007$). No significant difference was noted between the groups in the resting posture. However, the MTrPs group demonstrated greater difference in stiffness (working-resting posture) (DSWR) on the Rt side of the UT muscle (MTrPs, 62.61 N/m; non-MTrPs, 31.56 N/m; $p = 0.019$).

Conclusion: Clinicians should consider measuring muscle stiffness in the working posture and DSWR.

Keywords

assembly worker, muscle stiffness, myofascial trigger points, resting posture, upper trapezius, working posture

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Introduction

Myofascial trigger points (MTrPs) are hypersensitive spots within taut bands of the skeletal muscle, classified as active and latent based on pain perception upon palpation.[1,2] Active MTrPs are spontaneously painful, while latent MTrPs are painful under compression, often associated with motor dysfunction, such as stiffness and restricted range of motion.[1,2]

Muscle stiffness is a primary complaint among individuals experiencing musculoskeletal pain.[1,3] However, studies focusing on measuring upper trapezius (UT) muscle stiffness in female assembly workers are scarce. Hao et al.[4] reported that individuals with MTrPs exhibited greater UT muscle stiffness than asymptomatic individuals as measured using shear wave elastography. However, a handheld myometer is more commonly used in clinical settings because of its portability and practicality.[5,6] Despite its widespread use, few studies have examined UT muscle stiffness in female assembly workers with MTrPs.

Previous studies have assessed UT muscle stiffness in various resting positions, including sitting, standing, supine, and prone positions.[7–9] Viir et al.[7] reported a 20% decrease in UT muscle stiffness when transitioning from sitting to supine positions, while sitting and standing positions showed similar stiffness. Similarly, Maher et al.[8]

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found a 21% decrease in stiffness during the transition from sitting to prone positions. However, many clinicians measured UT muscle stiffness in the sitting position,[9–13] which may better represent daily life conditions than supine and prone positions.

The UT muscle is a prevalent site for MTrPs among female assembly workers, likely due to repetitive upper limb movements during work.[14,15] Furthermore, female individuals have a higher prevalence of work-related musculoskeletal disorders, with over a 46% 12-month prevalence of neck and shoulder symptoms compared to male individuals.[16] Therefore, assessing UT muscle stiffness in the working posture of female assembly workers is necessary for evaluating and preparing interventions for MTrPs. In this study, we aimed to identify differences in muscle stiffness measured in resting and working postures among female assembly workers with and without MTrPs in the UT muscle. We hypothesized that female assembly workers with MTrPs would exhibit higher UT muscle stiffness in the working posture than those without MTrPs.

Methods

Study design and participants

This was a cross-sectional observational study. The sample size was calculated using G* Power v. 3.1.9.6 (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) based on prior research on UT muscle stiffness in office workers.[9] With an effect size of 1.055 and a power of 0.8, a minimum of 16 participants was required for each group. Considering a 10% dropout rate, we recruited 36 female assembly workers through local community advertisements. Eligible participants were female assembly workers aged 20–50 years, with a body mass index (BMI) of 18.5–29.9 kg/m^2, a work duration of > 6 months, and right (Rt)-hand dominance.[9] Participants were divided into MTrPs and non-MTrPs groups based on pressure algometer readings and self-reported pain scores assessed by an experienced physiotherapist with 8 years of experience. The MTrPs group included participants who met the following criteria: (1) nontraumatic Rt UT muscle pain lasting > 3 months, (2) presence of tender point in the Rt UT muscle, (3) a numeric pain rating scale (NPRS) > 3, and (4) a Rt UT muscle pressure pain threshold (PPT) < 2.0 kg/cm^2 and left (Lt) UT muscle PPT > 2.0 kg/cm^2.[17,18] The inclusion criteria for the non-MTrPs group were as follows: (1) absence of UT muscle pain for at least 3 months, (2) an NPRS of 0, and (3) both UT muscle PPT > 2.0 kg/cm^2. The exclusion criteria included surgery or injury in the neck and shoulder regions, as well as diagnoses of orthopedic, neurological, or psychological disorders.[9,18] Prior to study initiation, the participants were informed concerning the details of the procedure and provided informed consent. The study was approved by the Institutional Review Board of Yonsei University Mirae Campus (approval number: 1041849-202212-BM-232-02). This study was conducted in accordance with the tenets of the Declaration of Helsinki.

Instrumentation

Upper trapezius (UT) muscle pressure pain threshold (PPT). To categorize participants into two groups, the PPT in both UT muscles was assessed using a Wagner FDX-25 (Wagner Instruments, Greenwich, CT, USA). This pressure algometer has demonstrated excellent intra-rater and inter-rater reliability (0.79–0.97).[19] An experienced physiotherapist applied the device to the UT muscle with a pressure increment of 1 kg/cm^2 per second. The PPT was determined based on the point when the participant first perceived pain or discomfort. Two trials were conducted on each side in the sitting position, and the mean of these trials was used as the PPT value for each side.

Cervical flexion angle (CFA). To confirm the effects of the cervical flexion angle (CFA) on UT muscle stiffness during the working posture,[10,12] a Smart KEMA motion sensor (Korea Tech Co., Ltd, Seoul, Korea) was used, measuring kinematic data. This motion sensor has demonstrated excellent intra-rater and inter-rater reliability, ranging between 0.95 and 0.99.[20] Positioned at the midline of participants' foreheads using an adjustable strap, the motion sensor was calibrated with the participants standing aligned with the plumb line. Kinematic data during the working posture were recorded at a sampling frequency of 25 Hz and transmitted to Smart KEMA software on an Android tablet.[21] The motion sensor on the x-axis represented the CFA, and measurements were performed twice, with the mean value used for analysis.

Upper trapezius (UT) muscle stiffness. The measurement of UT muscle stiffness was conducted at the midpoint between the acromion and the C7 spinous process using MyotonPRO (Myoton AS, Tallinn, Estonia).[9,11] The intra-rater and inter-rater reliabilities of this device were both 0.97.[11] To ensure consistency in the measurements, all assessments were conducted by an experienced physiotherapist. A 3-mm diameter of device probe was placed perpendicularly to the skin surface with an automatic preload of 0.18 N. Subsequently, eight brief mechanical impulses lasting 15 ms each were delivered at a force of 0.4 N and a frequency of 1 Hz to induce muscle oscillations.[22] The device performed three consecutive measurements at the same location and automatically calculated the average value. Muscle stiffness (N/m) represents the tissue's resistance to external force-induced deformation,[7] with higher values indicating greater muscle stiffness.

Table 1. Demographic information, pain intensity, and CFA in the working posture of the participants.

	Non-MTrPs group (n = 18)	MTrPs group (n = 18)	t	p
Age (years)	35.22 ± 3.78	33.17 ± 3.85	1.615	0.116
BMI (kg/m^2)	22.11 ± 2.39	22.23 ± 2.72	−0.143	0.887
Rt PPT (kg/cm^2)	2.62 ± 0.62	1.78 ± 0.16	5.518	< 0.01**
Lt PPT (kg/cm^2)	2.72 ± 0.58	2.25 ± 0.18	3.275	< 0.01**
NPRS	0	6.11 ± 1.53	−16.95	< 0.01**
CFA (°)	25.53 ± 7.37	28.27 ± 9.1	−0.995	0.327

The values are presented as means ± standard deviations.
BMI, body mass index; CFA, cervical flexion angle; Lt, left; MTrPs, myofascial trigger points; NPRS, numeric pain rating scale; PPT, pressure pain threshold; Rt, right.
**$p < 0.01$

Table 2. MANOVA results for UT muscle stiffness and DSWR.

	Wilk's lambda	F	df1	df2	p	η_p^2
UT muscle stiffness (N/m)	0.632	4.52	4	31	0.005	0.37
DSWR[a] (N/m)	0.722	6.36	2	33	0.005	0.28

MANOVA, multivariate analysis of variance; UT, upper trapezius; DSWR, difference in stiffness (working-resting posture).
[a]The DSWR was calculated by subtracting the UT muscle stiffness value in the resting from working posture.

Experimental protocol

Resting posture. The participants were seated on a chair with their palms facing down on their knees. A small circle was marked at the midpoint between the acromion and C7 spinous process using a non-toxic marker. Then, UT muscle stiffness was assessed bilaterally while the participants maintained a relaxed, upright position.

Working posture. In the laboratory setting, participants stood in front of an adjustable table positioned approximately 5–6 cm below the styloid process of the wrist.[23] Prior to the task, participants familiarized themselves by simulating their typical work activities, including inspection, assembly, and packaging, for 1 min. During the experiments, participants performed the working task for 1 min, repeated twice. After each task, participants halted their motion, and the CFA was measured. Subsequently, in the second task, participants held a smartphone (Galaxy S21; Samsung Inc., Seoul, Korea) with their hands, and the examiner adjusted their position to achieve an elbow flexion, shoulder flexion, and shoulder abduction of 90°, 0°, and 0°, respectively. This adjustment aimed to minimize the influence of shoulder movements on UT muscle stiffness.[11,13] The marked points were used as references for measuring UT muscle stiffness on both sides.

Statistical analysis

The Shapiro–Wilk test was conducted to assess the normality of data distribution. All outcome variables were normally distributed ($p > 0.05$). The independent t-test was used to examine the differences in demographic data, pain intensity, and CFA between individuals with and without MTrPs. The difference in stiffness (working-resting posture) (DSWR) was calculated by subtracting the resting stiffness values from the working stiffness values in the UT muscle. Multivariate analysis of variance (MANOVA) was used to examine group differences in UT muscle stiffness because these dependent variables demonstrated moderate correlations (Pearson's r = 0.486–0.749), fulfilling the assumptions of MANOVA. Box's M test confirmed the equality of covariance matrices for both comparisons (UT muscle stiffness, $p = 0.056$; DSWR, $p = 0.089$), thereby meeting the assumption. Additionally, Levene's test verified the homogeneity of variance, as all dependent variables showed p-values greater than 0.05. The significance threshold for the independent t-test was set at 0.05. To decrease the possibility of a Type I error, we applied the Bonferroni correction, yielding an adjusted p-value of 0.013 for the four stiffness measures (Rt and Lt UT muscle stiffness in both resting and working postures) and 0.025 for the two DSWR measures (Rt and Lt DSWR). All statistical analyses were performed using SPSS software (version 26.0; IBM Corp., Armonk, NY, USA).

Results

Demographic data, pain intensity, and cervical flexion angle (CFA) in the working posture

Thirty-six female assembly workers (18 in each group) participated in the study. No significant differences were noted in age and BMI between the groups (Table 1). Workers in the MTrPs group exhibited lower PPT and higher NPRS compared to those in the non-MTrPs group ($p < 0.01$). During work, the participants in the MTrPs group exhibited higher CFA than those in the non-MTrPs group. However, no significant differences in the CFA were observed between the groups ($p = 0.327$).

Upper trapezius (UT) muscle stiffness

The MANOVA results revealed significant differences in UT muscle stiffness and DSWR between the groups (Table 2).

Table 3. Comparison of UT muscle stiffness during the resting and working postures.

		Non-MTrPs group	MTrPs group	p	η_p^2
Side	*Condition*				
Rt (N/m)	Resting	303.67 ± 54.05	323.61 ± 54.03	0.276	0.035
	Working	335.22 ± 56.38	386.22 ± 50.97	0.007*	0.192
Lt (N/m)	Resting	301.28 ± 38.01	333 ± 51.05	0.042	0.116
	Working	336.94 ± 56.18	344.22 ± 46.16	0.674	0.005

The values are presented as means ± standard deviations.
Lt, left; MTrPs, myofascial trigger points; Rt, right; UT, upper trapezius.
*Statistically significant level was set at 0.013 for stiffness by Bonferroni correction.

Table 4. Comparison of DSWR in UT muscle stiffness between non-MTrPs and MTrPs groups.

		Non-MTrPs group	MTrPs group	p	η_p^2
	Side				
DSWR[a] (N/m)	Rt	31.56 ± 28.72	62.61 ± 44.92	0.019*	0.152
	Lt	35.67 ± 29.32	11.22 ± 45.60	0.064	0.097

The values are presented as means ± standard deviations.
Lt, left; MTrPs, myofascial trigger points; Rt, right; UT, upper trapezius; DSWR, difference in stiffness (working-resting posture).
[a]The DSWR was calculated by subtracting the UT muscle stiffness value in the resting from working posture.
*Statistically significant level was set at 0.025 for DSWR by Bonferroni correction.

Resting posture. The MTrPs group exhibited slightly higher Rt UT muscle stiffness compared to the non-MTrPs group, although this difference was not statistically significant ($p = 0.276$) (Table 3). Similarly, the Lt UT muscle stiffness was not statistically different between the MTrPs and non-MTrPs groups.

Working posture. In the MTrPs group, Rt UT muscle stiffness was significantly higher than that in the non-MTrPs group ($p = 0.007$). The Lt UT muscle stiffness was comparable between the groups ($p = 0.674$).

Difference in stiffness (working–resting posture) (DSWR). The MTrPs group showed a significantly greater DSWR in the Rt UT muscle stiffness compared to the non-MTrPs group (Table 4). In contrast, the DSWR in Lt UT muscle stiffness was not statistically significant ($p = 0.064$).

Discussion

Our study investigated muscle stiffness in both resting and working postures among female assembly workers with and without MTrPs. Although measurements were conducted on both sides, the study focused on participants with Rt-hand dominance and Rt UT pain for the MTrPs group, highlighting the clinical significance of findings related to the Rt side. We found no notable differences in UT muscle stiffness in the resting posture (Figure 1A, B). However, in the working posture, UT muscle stiffness on the Rt side was higher in the MTrPs than in the non-MTrPs group.

Although previous studies have measured UT muscle stiffness using a handheld myometer,[9,22] to our knowledge, this is the first study to compare UT muscle stiffness on each side in female individuals with and without MTrPs. Previous studies have reported UT muscle stiffness values in the sitting posture, ranging from 285.1 ± 39.5 N/m for the normal head posture group to 301.5 ± 23.5 N/m for the neck pain group among female office workers.[9,22] In our study, the MTrPs group showed Rt side stiffness at 323.61 ± 54.03 N/m, while the non-MTrPs group showed Rt side stiffness at 303.67 ± 54.05 N/m in the resting posture. Although slightly higher than previous reports, our findings fall within the standard deviation of previous research.[9,22]

A recent study using shear wave elastography revealed that patients with MTrPs exhibited significantly higher mean shear wave velocity on both affected and unaffected sides of the UT muscle (4.41 m/s and 4.05 m/s, respectively) compared to that in normal volunteers (3.35 m/s).[4] This contrasts with our results, where no meaningful difference in UT muscle stiffness was observed between the groups in the resting posture. This discrepancy could be attributed to differences in instruments and participant selection. Shear wave velocity can be affected by the preload applied by the probe,[24,25] whereas muscle stiffness measurements obtained using a handheld myometer apply a consistent, automatic preload. Additionally, our recruitment approach for the non-MTrPs group, using a pressure algometer and perception of pain, aimed to eliminate the possibility of including latent MTrPs, potentially lending greater significance to our findings concerning the presence of active MTrPs.

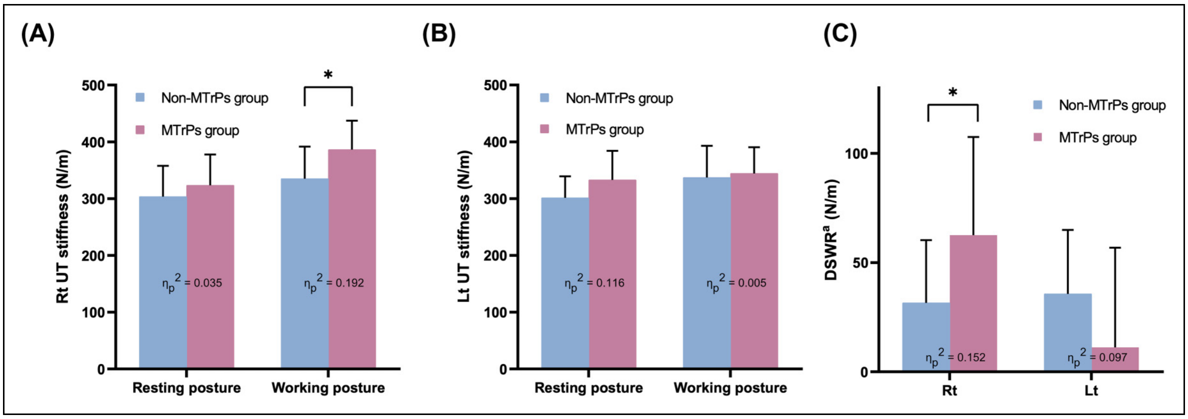

Figure 1. Comparison of UT muscle stiffness during the resting and working postures: (A) Rt side, (B) Lt side, and (C) DSWR. Lt, left; MTrPs, myofascial trigger points; Rt, right; UT, upper trapezius; DSWR, difference in stiffness (working-resting posture). *Statistically significant level was set at 0.013 for stiffness and 0.025 for DSWR by Bonferroni correction. [a] The DSWR was calculated by subtracting the UT muscle stiffness value in the resting from working posture.

Understanding the pathophysiological mechanism behind MTrPs[1,2,26] is crucial. Muscle overload can activate MTrPs, leading to pain perception, which may transition to latent MTrPs with rest.[1,2] In this study, we focused on "overload," referring to acute, sustained, and repetitive direct stimuli. By assessing stiffness during the working posture, which poses greater demands than the resting posture, we observed significantly higher Rt UT stiffness in the MTrPs group compared to the non-MTrPs group (Figure 1A). The UT muscle, as a postural endurance neck muscle, is often overused due to repetitive arm movements and prolonged static working posture.[27] Hypercontraction of the sarcomere during the working posture might initiate an intense action potential, leading to muscle stiffness due to the sustained release of calcium in the sarcoplasmic reticulum.[1,2,26] This vicious cycle of contraction elevates the intramuscular pressure, reduces blood flow, and induces local ischemia. The resulting oxygen deficit impairs ATP synthesis, disrupts calcium homeostasis, and promotes the formation of taut bands.[1,2,26] In our study, sustained overload in the working posture may have led to an energy crisis, providing a plausible physiological explanation for the increased UT muscle stiffness in the working posture and the DSWR observed in the MTrPs group. Our findings support the hypothesis that sarcomere hypercontraction, ischemia, and energy crisis contribute to increased muscle stiffness in individuals with active MTrPs.

In contrast to our findings, a previous study examining neck muscle stiffness during various tasks in female individuals with and without chronic neck pain found no differences in muscle stiffness between the groups.[27] However, the results might differ because their tasks did not include cervical flexion. Furthermore, while the previous study used average stiffness values for neck extensor muscles or across all tasks, our study used stiffness values specific to each muscle for each task. Our findings demonstrate a more considerable difference in DSWR between female individuals with and without MTrPs in UT muscle stiffness (Figure 1C). This highlights the significance of UT muscle stiffness in the working posture and DSWR, providing meaningful insights into the evaluation of MTrPs.

The clinical relevance of our findings is that Rt UT stiffness in the working posture, rather than in the resting posture, showed a large effect size of 0.192. This suggests that muscle stiffness in the working posture may be an ergonomic risk factor and could be a target for intervention. Additionally, the effect size for the DSWR in UT muscle stiffness was 0.152, further supporting the results of prior studies.[28–30] The DSWR reflects measurable changes in muscle stiffness between postures, offering valuable insights for monitoring muscle properties in individuals with MTrPs. In practical ergonomic interventions, it is recommended to adjust workstation environments, such as table height and lifting weight settings, as well as to correct awkward postures, and reduce repetitive movements.[28–30] Further studies are required to investigate whether modifications to ergonomic settings can decrease UT muscle stiffness in individuals with MTrPs.

The measurement of UT muscle stiffness is reportedly influenced by several factors, such as increased CFA, shoulder flexion, and abduction,[10–13] resulting in stiffness increments ranging 14–55%.[10–13] To minimize these effects, we measured UT muscle stiffness at 0° of shoulder flexion and abduction. Additionally, we assessed the CFA during working posture and found no significant differences between the groups. These findings suggest that the differences in UT muscle stiffness measured in the working posture could be attributed to the presence of MTrPs. However, we did not explore the causal relationship between MTrPs and muscle stiffness. Future research should investigate this relationship further to elucidate underlying mechanisms.

Our study had some limitations. First, we focused only on female assembly workers due to their elevated prevalence of neck and shoulder pain.[16] Additionally, the relatively small sample size may have limited the statistical power and generalizability of our findings. Future studies should include larger and more diverse populations, including male workers and individuals from various occupational backgrounds, to validate our results. Second, although our experiment simulated real-world assembly work, its short duration may not fully reflect the prolonged and repetitive nature of the tasks. Future studies should extend the task duration or include multiple repetitive cycles to more accurately reflect the actual working conditions. Third, variability in probe placement or tissue compliance when using MyotonPRO could influence stiffness measurements. While our study employed a widely used method of placing the probe at the midpoint between the acromion and the C7 spinous process, future research should investigate the effects of different measurement locations, particularly concerning MTrPs distribution. Fourth, electromyography was not conducted on the UT muscle under resting and working conditions. Future studies are needed to investigate UT muscle stiffness and activity in both resting and working postures.

Conclusion

The UT muscle stiffness in the resting posture showed no notable difference between female assembly workers with and without MTrPs. However, MTrPs group demonstrated greater UT muscle stiffness than non-MTrPs group in the working posture. Furthermore, MTrPs group exhibited higher DSWR values. Therefore, we suggest that clinicians should assess muscle stiffness in both resting and working postures to effectively evaluate MTrPs.

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Ethical considerations

The study was approved by the Institutional Review Board of Yonsei University Mirae Campus (approval number: 1041849-202212-BM-232-02). This study was conducted in accordance with the tenets of the Declaration of Helsinki.

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Declaration of conflicting interests

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Informed consent

Prior to study initiation, the participants were informed concerning the details of the procedure and provided informed consent.

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